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UNUSUAL MODES OF BREEDING AND DEVELOPMENT AMONG ANURA.

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IT has been my good fortune to obtain from Jamaica a complete series of stages of the development of *Hylodes martinicensis*. The eggs of this frog are deposited on land, and the entire development takes place within the egg-membranes. The stages that correspond to the tadpole of our common frogs are passed through inside the egg-membrane and a fully formed frog emerges at the time of hatching. In connection with the study of the development of Hylodes it has been necessary to collect the descriptions that have been given of exceptional modes of development in the Anura. These accounts are often very fragmentary and widely scattered, so that no small labor has been necessary to bring together the literature of the subject. In the hope that a consecutive and full account of what is known may be of service to others, the following pages have been prepared.

In the groups of fishes and Amphibia the eggs are generally laid in large quantities and are left unprotected, but there are other exceptional modes of propagation in species of

unrelated genera and families. In these cases protection of some sort is generally afforded to the young, or else they have become adapted to an unusual environment. As a result, modifications in the young have been produced, as well as changes in the instincts and even in the anatomy of the parents. Examples among fish are the various cases of nest builders among teleosts; the cases of Bagrus, of the siluroid Chromis, and of other fish that carry the young in the mouth for a longer or shorter period; the case of *Asprædo lævis*, in which the female carries the eggs and young attached to pedicels on the abdomen; the cases where the male fish is provided with a temporary or permanent pouch for the young, and the cases of partially or entirely viviparous forms among teleosts and selachians. Examples among Amphibia are the viviparous salamander; Plethodon and Autodax, which lay their eggs on land; Desmognathus, Amphiuma, and the Cœcilia, where the eggs are laid in damp places and are surrounded by the parent's body; and a number of Anura, which are the subject of the present paper. For the sake of comparison with what is to follow, the salient points in the development of the common frog may be briefly stated. The eggs are laid in large numbers in water, where the larvæ develop. The newly hatched tadpole adheres at first to a fixed object by means of an adhesive gland, but after a few days it becomes free-swimming. It possesses at first external gills; these are replaced by internal gills, covered by the characteristic operculum; the internal gills are in turn gradually replaced by lungs; in the mean time the hind legs and later the fore legs develop; the tail is absorbed, the shape and position of the mouth are changed, the larval "mouth-parts" are cast off, and the characteristically coiled intestine is shortened. The metamorphosis transforms the aquatic larva into the adult air-breathing form.

This general account is true for all the common frogs and toads of North America and Europe, with the exception of Alytes. The Anura of other regions, especially in the Tropics and the Southern Hemisphere, far from having uniform breeding habits and one mode of development, vary

in many ways. For the sake of completeness, a number of forms will be mentioned that are often referred to in connection with those that have an unusual mode of development; they are forms whose embryology has been but little, if at all, investigated, but whose development takes place under somewhat unusual conditions, so that the embryology is a question of interest.[1]

The eggs of the Japanese frog, *Rhacophorus schlegelii*, are laid from the middle of April to the middle of May in excavations prepared by the female in the muddy banks of paddy-fields, ponds, lakes, etc., 10 to 15 cm. above the water line. As the eggs are laid, they are fertilized, and the gelatinous substance about them is aërated by a kneading motion of the hind legs of the female. Both adults usually escape from the nest by breaking a hole in the side of the bank exposed to the water. The frothy egg-mass hardens on the outside, and within it the tadpoles hatch. The substance about the eggs gradually collapses, and in time flows into the water, carrying with it the tadpoles. The eggs are about 1 mm. in diameter, and devoid of pigment until the tadpole stage, when pigment begins to show in the pectoral region. The segmentation is said to be unequal and holoblastic, though more nearly meroblastic than in any other amphibian egg.[2] The embryo is described as resembling a ganoid embryo, the head being flat upon the yolk, and the body wedged into the large yolk-mass.

It is interesting to note that eggs taken from the nest in the mud invariably die if put into water.

Eggs that are said also to be those of Rhacophorus have been found in various localities in Japan, in a frothy, gelatinous substance on the leaves of trees overhanging the water. How the eggs are deposited is not explained.

Two other frogs, from different parts of the world, leave their spawn on trees, in nests formed of leaves stuck together. One of these, the West-African *Chiromantis guiniensis*, is found

[1] For an index to the forms discussed, with summary of literature referring to each, see Appendix, p. 714. References to reviews are given after special articles.

[2] The segmentation of several other anuran eggs that contain much yolk has not as yet been described.

in Cameruns, Victoria; the other, *Phyllomedusa iheringii*, in the province of Rio Grande, Brazil. In both cases hatched tadpoles have been seen, moving with considerable freedom, in the frothy mass in which the eggs are laid. The nest of the Phyllomedusa has an inferior opening over the water. It is believed that the tadpoles of Chiromantis are washed off the leaves by rain. Tadpoles, hatched in confinement, at first swam in the gelatinous substance which liquefied about them, and being transferred to water, they lived and developed. The account of Chiromantis opens with an exclamation on the remarkable character of the metamorphosis of the frog, and yet the tadpoles are described as having a "rudder-tail, a clump of gills, etc., just like an ordinary tadpole," and they "developed (in water) in the usual way."

The little *Phyllomedusa hypochondrialis*, in Paraguay, selects for the deposition of its eggs a single leaf on a plant near a pool, or over it, not more than two feet above the water. The female carries the male, until a suitable leaf is found; then both frogs hold the tip of the leaf together with their hind legs, and in the funnel thus formed the eggs are deposited, the frogs moving up the leaf as the bottom is filled. One pair of frogs may make two nests with about 100 eggs in each. The eggs contain much yolk and measure 2 mm. in diameter. If put into water, the eggs die, but develop if they are simply kept moist. The tadpoles hatch and escape from the leaf into the water after six days; if the nest has not been directly over the pool, the tadpoles may move (assisted by a jumping motion) several inches along the ground during a shower.

Segmentation is holoblastic, but not very regular; the blastopore closes and a new anus is formed. The embryo at first lies flat upon the yolk, but before the yolk is absorbed the embryo is modeled high up upon it, and the head and tail are entirely separate from it. The yolk is covered by a plexus of vitelline veins.

Three visceral pouches, the 1st, 2d, and 3d branchial, are formed, and external gills appear first on the 1st branchial arch and later on the 2d. The first pair grow rapidly and soon become very long, branched filaments; the second pair

never develop to the same extent. No adhesive gland is formed. When the external gills are developed the tail has grown to a large size and has so ample a blood supply from the dorsal aorta and cutaneous veins that it is supposed to be an important organ of respiration. After hatching, the tip of the tail often vibrates rapidly, perhaps to insure the flow of a constant stream of water over the tail.

Before hatching, the operculum grows back from the hyoid arch, and has a median spiraculum; the external gills are rapidly absorbed, and internal gills are developed. The stomodæum breaks through, at the last stage in the egg, and the tadpole hatches as a free-swimming, transparent larva, with prominent eyes, and with no longer any trace of yolk. The lungs are present. On the day after hatching, pigment appears in the larva.

Five weeks later the hind legs begin to develop, and the tail is absorbed very rapidly, until only a little of it remains. After the legs are formed the frog leaves the water, and the final absorption of the tail takes place on land.[1]

The eggs of *Hyla nebulosa*, found in Rio de Janeiro, hatch in a frothy mass in the sheath of withered banana leaves, but not near a pool. Unlike the tadpoles of Chiromantis, which probably reach the water in the natural course of events, the tadpoles of *Hyla nebulosa* invariably die if they are transferred to water.

The tadpoles of *Cystignathus* (*Paludicola*) *gracilis* in Brazil, and of a frog believed to be *Rhacophorus eques* in Ceylon, are said to undergo part, at least, of their development out of water. The eggs have been found in frothy masses on land, those of Cystignathus usually in the grass in the neighborhood of pools. The adult Cystignathus, and on one occasion two young, were found under decaying trunks of trees, near dried ponds; the larger of the two young possessed the vestige of a tail. The naturalist d'Orbigny found the same species in the Argentine Republic, where it occurs under pieces of wood, near the borders of lakes that are common in the sandy soil. The tadpoles of Rhacophorus were observed superficially and are said to resemble those of the ordinary frog.

[1] For further details, see Budgett ('99).

The adult of the Brazilian frog, *Cystignathus mystaceus*, in the province of Rio Grande do Sul, never goes to water, even to spawn. In the breeding season it prepares a hole under a stone or decayed wood, near the edge of a pool, but above the water line; here the eggs are deposited in comparatively small numbers. The frothy substance about them probably serves as food for the tadpoles, since it diminishes in quantity as they grow. In a dry season the tadpoles may attain great size in the nest, but ordinarily they are washed into the pool, when, after a rain, it overflows. They probably do not go through the entire metamorphosis in the nest, however long they may be detained in it, for tadpoles that had grown there to a considerable size still possessed tails. During development in the nest, external gills were observed; the tail was thought to be not so powerful as that of *Rana esculenta*, and is at first light in color, like the egg, but later becomes pigmented dorsally. Another Brazilian nest builder is *Hyla faber*, which is common in Rio de Janeiro, especially in the mountain regions. The female constructs for the eggs a shallow vessel of mud, about four inches high and a foot in diameter. The nest is carefully built on the bottom of a pool, with its edge projecting above the water. Similar nests have been found in Rio Grande do Sul,[1] and there it has been observed that, if the pool dries, the tadpoles in their little lagoons perish, while the young of *Cystignathus mystaceus* survive, huddled together in the frothy substance in their nest in the bank. The eggs of *Cystignathus typhonius*, a frog common in Porto Rico, have been found under conditions similar to those described in the case of *C. mystaceus*. The tadpoles swam when put into water. The appearance of the hind legs and of the fore legs and the disappearance of the tail were observed.

In Ceylon, a green frothy spawn, about the size of a crow's egg, has been found sticking to the walls of cisterns, to perpendicular rocks of quarries over water, and to the damp

[1] It was formerly supposed by the observer in Rio Grande do Sul that such nests were constructed by *Cystignathus ocellatus*, but there is good reason to suppose that *Hyla faber* is the artisan. In Rio de Janeiro this frog has been observed in the very act of building, which takes place at night.

trunks of trees. After some discussion it has been decided that the spawn is that of *Polypedates maculatus*. A very similar account is given of the blue spawn of *Rana temporalis*, also found in Ceylon. The two descriptions agree so closely that one is led to suspect that the two cases may be one and the same.

The tadpoles of a Brazilian frog, *Hyla* (*Ololygen*) *abbreviata*, have been found in cracks of rocks. The abdomen of the tadpole is flat and serves as a sucker, so that if the perpendicular rock is slightly moist, the tadpole can move rapidly over it without legs. The tail is round, with a fin only at the end; on the ventral side the fin is anteriorly converted into a sole, which probably aids the tadpole in adhering to the rock. The mouth is large and the lips are unusually developed. It is said that the frogs, for a time after metamorphosis, are the color of the rocks. Nothing is recorded as to where the eggs are laid, or how they develop.

The breeding habits of *Pipa americana*,[1] commonly known as the "Surinam toad," have been a subject of observation, still more of discussion, from time to time for more than a century. It has been found in British as well as in Dutch Guiana. The frogs are said to be essentially aquatic, and rarely to leave the water. The eggs are laid in the dry season, when the temperature is exceedingly high. The earlier accounts of spawning are probably based on the observations made by Fermin in Surinam, and published in 1765. He states that the eggs are laid on the sand and are placed by the male on the back of the female; a few minutes after fertilization the female returns with them to the water and swims off. The spawning has recently been described in a different way, as observed on one occasion in the Zoölogical Gardens of London. The animals remained in the water, the oviduct was protruded into a bladder-like pouch, turned up over the back; the male clasped the female, and pushed the eggs out of the bladder, leaving them evenly distributed over the back of the female. It is supposed that the eggs are fertilized in the ovipositor.

[1] A few embryos of Pipa have been in the possession of the Warren Anatomical Museum of the Harvard Medical School.

The dorsal skin of the female thickens about the eggs, until each is enclosed in a dermal "cell" or sac, which is finally covered by an "operculum." Leydig ('96) regards the cells as modified glands, and, in corroboration of his view, states that other dermal glands are not found where the cells are formed; he regards the cap of the cell as a secretion of the gland, while formerly it was thought to be a hardened portion of the gelatinous substance around the egg. Whatever the origin of the cells, they are temporary structures which form in response to the stimulus of the eggs; the number of eggs carried by one frog has been variously estimated, and may be more than one hundred.

The eggs develop entirely within the dermal cells, and Fermin has observed that they remain about eighty-two days on the back of the parent. I have found no direct statement as to whether the time of hatching is coincident with the time of leaving the dermal sac, except in Bronn's Thierreich. There it is said that "the hatched young find shelter and nourishment on the parent's back, until after completed metamorphosis," implying that the eggs are hatched some time before the young escape.

The only description of development, based on the observation of many embryos, is one by Jeffries Wyman ('54), giving the external characters of three stages.

The limbs develop early; even in the youngest stage, where there were three pairs of external gills, the fore and hind legs were present, in the condition of knobs at the sides of the embryo, the posterior said to be unconnected with the trunk. There were at this stage vitelline vessels, supplying the large yolk-mass. The head was broad and flat, with conspicuous cerebral vesicles and prominent pigmented eyes; the spinal cord was closed.

Later (in the second stage), when the external gills had disappeared, fringed branchial arches were seen by removing the dermal folds which concealed them; the opercular folds opened by a small branchial fissure on each side of the neck, and judging from the figures, did not cover the anterior legs. Rudiments of feet were present on all the extremities. It is

said that the whole yolk-mass was invested with a "tunic" and converted into a spiral intestine, returning to the trunk through the middle of the coil! The nostrils in this stage were seen as round terminal depressions.

In the last stage toes were formed; the skin was furnished with papillæ and protuberances; the intestine had increased in length and was still coiled; the mouth, as in the preceding stages, was placed under the head, at a little distance from the anterior end. Another account states that the horny jaws are not developed. The tail in all embryonic stages was provided with the usual muscles as if for swimming, and was folded against the side of the egg. Wyman shows that, after the supply of gelatinous substance around the egg has been exhausted, the tadpole still continues to increase in size, and he concludes that it must therefore grow at the expense of material from the mother, probably by a secretion of the wall of the cell. In summing up the development of Pipa, Wyman notes that the embryo goes through the usual metamorphosis, having internal and external gills and lungs, also a tail adapted to swimming, although the gills and tail are never used as in the frog. The external branchiæ are lost at a very early period, and the tail is absorbed before the animal escapes from the back of the parent.

The folds of skin covering the internal gills differ from the operculum of the frog in that they open on both sides, and the anterior legs are not covered by them. These relations are similar to those in the larva of Dactylethra, the other representative of the primitive suborder of Aglossa. The presence of external gills has been doubted at various times, but the balance of evidence and the last word on the subject seem to show that they exist for a short period.

An early writer, according to subsequent quotations, affirmed that the tail is devoid of pigment, and believed that it is an embryonic breathing organ. This idea was entertained at a time when the presence of gills was not known; it is not in accordance with Wyman's account, nor with Spallanzani's (1785), who concluded, after a careful examination, that the tail does not differ from that of the ordinary tadpole. Furthermore,

Bronn and Balfour state that the tail is absorbed before hatching, and Bronn has implied, as already mentioned, that the hatched young remain for a time on the parent's back. If these statements be true, and if it were also true that the tail assumes the function of respiration, then the animal would be deprived of the embryonic breathing organ some time before it escapes from the cell on the parent's back.

Alytes obstetricans[1] is unique among European frogs in not laying its eggs in water. It occurs in various parts of Europe, such as the Rhine region in Germany, the neighborhood of Marbourg, Paris, and Liège. It has been said that it lives only in regions of hilly ground, where there are clear springs; but Cope ('85) records that it is common in dry places near Berlin. The frog digs skillfully, and remains underground by day, but at night it is active in the search for food.

The eggs are laid from March to June (according to locality), in a double string of gelatinous substance. The male loops the eggs about its hind legs in the form of a figure 8, and thus carries them, for about three weeks, when the young have reached a stage of development far beyond that of the typical tadpole at the time of hatching. At the end of the period the male takes the eggs to water, and there the tadpoles leave the egg-membrane, and at once swim about actively. They are said to winter in the tadpole stage, although Claus ('66) has affirmed that the metamorphosis is completed in a month. When the tadpole leaves the egg, the external gills are already reduced, and the internal gills are fully developed; the opercular opening is median; the tail is ready for swimming; the lungs are developed; the horny jaws, teeth, and fringed lips are formed (these are said to appear later than in the ordinary frog); the intestine is coiled, and the liver is present; the head kidney is in process of degeneration, and the mesonephros partially developed; the legs are not formed. It has been suggested that the lungs are used before hatching, because air bubbles are given off as soon as the tadpoles reach the water.

[1] A complete account of Vogt's ('42) article is not given here. Gasser ('82) also describes details not mentioned here, especially in regard to the blastopore, the germ layers, and the development of the pronephros and kidneys.

The egg contains an unusual amount of yolk, and is not pigmented; the segmentation was formerly thought to be meroblastic, but it has recently been described as similar to that of Bombinator. The embryo is said to be ciliated even on the head. Certain peculiarities in the development of the alimentary canal have been recorded. The cavity is at first wide, and in the foregut and hindgut it remains in this condition, the anterior end having the widest lumen; in the middle region the ventral yolk-mass is raised in a ridge, toward the dorsal wall, so that the midgut is, for a time, nearly or entirely barricaded. An early description seems to indicate that the œsophagus is at one time closed by yolk-cells, as in the frog. The liver is said to develop independently, and shortly to acquire an opening into the alimentary canal. It is also said that the vitelline veins are at first not connected with the liver, but pass into it later as the portal vein. The lungs arise as solid masses of cells in the œsophageal region, and subsequently become hollow. An adhesive gland is not mentioned.

Before the gills develop, four gill-slits break through; the external gills are then represented by a single pair, on the third visceral arch; they grow to an unusual length during the life in the egg, and are branched eight or ten times. These delicate plumes are very highly vascular and therefore bright red, and are easily seen through the egg-membrane.

When the tadpoles are about ready to leave the egg, the hatching may be hastened or retarded within the limits of two or three days, by bringing the eggs into water a little before or after the normal time. Tadpoles that were put into water long before the usual time, for example when the external gills were fully developed, fruitlessly turned within the egg-membrane, and finally died.[1] On the other hand, Agassiz tried without success the converse experiment of raising the newly hatched young in air.

Some interesting facts have been discovered in connection

[1] The experiment of first cutting away the egg-membrane and then leaving the tadpoles in water was apparently not tried. Compare experiments on the embryos of the viviparous *Salamandra atra*. Those taken from the uterus, if tended with great care, cast off their gills in water and develop a new set. Chauvin ('77).

with the Venezuelan frog *Nototrema oviferum* (*Notodelphys ovipara, Opisthodelphys oviferum*), found at Puerto Cabello. The female is provided with a large dorsal pouch, which opens to the outside at its posterior end. It has been regarded as an invagination of the skin, and unlike the dorsal cells of Pipa it is a permanent organ. Weinland ('54) has described fifteen embryos that were contained in the pouch of one specimen, and had all reached the same point in development. They measured 18 mm. from head to tail, and were folded over a large yolk-mass, that formed about seven-eighths of the egg. The embryos were dark with pigment, but over the yolk there were only scattered pigment cells. The rudiments of body muscles are described as present beneath the skin about the yolk. The head was well defined and of the shape peculiar to the adult, with prominent eyes and semicircular nasal openings. The mouth was ventral near the anterior edge of the head, and measured little less than one-half the width of the head. It is said in the course of the description that the horny jaws were not developed, although at another place in the same account the embryo is paralleled, in respect to the mouth, with the newly hatched Alytes, where the tadpole mouth-parts are present.

In the embryo of Nototrema no adhesive gland was found, and the tongue was not developed. The fore legs measured about 2 mm. and were concealed beneath the operculum; the hind legs were twice as long, the toes were forming. The tail measured 5 mm. in length and 2 mm. in width, and with the hind legs was laid against the side of the egg. The heart was three-chambered, and the aortic arches separated not far from it. The dorsal aorta, posterior vena cava, and portal vein from the gut to the liver were large vessels. The lungs were well developed. The three-lobed liver, the gall bladder, and large pancreas were present, the pancreas surrounded by a coil of gut, leading to the stomach portion. The foregut and also the hindgut were thick-walled and appeared white, while the gut between them was formed of coils packed with yellow yolk. The pronephros had entirely disappeared, and the fat bodies and the kidneys were present.

The most remarkable structures were the gills. Three visceral arches were present, and according to one statement three gill-slits (three slits appear in the figures, but in another part of the description it is said that the first and third arches have each only one free edge — a condition that would admit of only two slits). The gills consisted of a pair of very thin bell-shaped membranes, each gill connected with the gill arches by two filaments, one ending on the first and one on the second arch. This peculiar arrangement led Weinland to the conclusion that the bells represent two gills fused together. He regarded them, in function at least, as external gills. On the free edge of the third arch was found the rudiment of what was supposed to be an internal gill, which suggested that the bell-gills are temporary larval organs. The bell-gills were veined by a capillary network, and the vessels were filled with blood, so that the gills were probably already functioning, although pressed close to the embryo in the egg; it was only after floating them out in water that their windflower shape and large size were discovered. The gill measured across, when expanded, not less than three-quarters of the diameter of the egg. The gill filaments were provided with striped muscle fibres; these muscles, Weinland argued, could not be of use in the egg, but the gills may be retained a short time after hatching, when the muscles might function in water, whether the tadpole remained within the pouch or escaped.

Weinland knew nothing of the subsequent history of the tadpoles, as to when they hatch and whether they ever live in water, either free or within the pouch; Boulenger makes some unqualified statements in regard to these questions.

He has noted the occurrence of eggs in the dorsal pouch of the female of *Nototrema fissipes;* he observed a single specimen, in which there were sixteen ova, measuring each 10 mm. in diameter. "From the size and small number of the ova," he writes, "it may be safely predicted that the young undergo the whole of the metamorphosis, within the pouch, as in *Nototrema oviferum*, which is the nearest ally of *Nototrema fissipes*." Of two species of Nototrema found in Ecuador and Peru, also provided with pouches, Boulenger says in an earlier work ('82),

"In *Nototrema testitudineum*, as in *Nototrema oviferum*, the young undergo their complete metamorphosis in the maternal pouch; while in *Nototrema marsupiatum* they leave the pouch in the tadpole state." The tadpoles of *Nototrema marsupiatum*, and those of another species, *Nototrema plumbeum*, are set free in water, according to Werner ('98).

Yet another frog of the tropical Andes, *Amphignathodon güntheri*, is said to have a dorsal pouch, which is probably a receptacle for eggs.

The female of a small Venezuelan species, *Nototrema pygmæum*, bears from four to seven young in a dorsal pouch, which splits open when the development of the tadpoles is complete. The pressure of the active young starts the splitting of the pouch at the slit-shaped posterior opening, and the whole pouch is laid open in the middle line. The pocket is perhaps formed from lateral folds after the eggs are placed on the back, and is possibly not closed again after the young escape, but is formed anew at the next breeding season; or the pouch is perhaps never formed a second time.

Observations on a number of tadpoles of *Rhinoderma darwinii* have disclosed some of the facts of the development of this interesting frog. It was first discovered on the voyage of the *Beagle*, in the shady forest of the province of Valdiera in Chile. It was formerly supposed to be oviparous, but, in reality, the tadpoles develop in an enormously expanded gular pouch, which covers nearly the entire ventral side of the male frog.

One account tells of fifty embryos in the pouches of five adults, and a much later account describes certain features of eleven tadpoles of one pouch. The tadpoles from one adult are not equally developed.

The youngest tadpoles described were thought to be just hatched. They measured 4 mm. to the tail; the alimentary canal was not differentiated, but contained much yolk. In all later specimens the alimentary canal was short, coiled, and of a yellow color, due to the presence of yolk. No external gills were observed, nor horny mouth-parts. Internal gills are not mentioned, although the anterior legs in young stages are concealed beneath a fold of skin (suggesting the operculum).

The hind legs develop before the fore legs and in late stages the feet are webbed. The tail is weak and small, and in the youngest embryos lies along the middle line of the egg-sphere. The oldest tadpoles had lost the tail, but at a period before its absorption both fore and hind legs were present and free.

The adults of *Hyla gœldii* have been found in Rio de Janeiro in water, contained in the central cup of certain Bromeliaceæ, and also on dry bamboo near Bromelia. The dorsal skin of the female is slightly raised around the edge of the back, forming a shallow cup, where the eggs are carried. In one case the dorsal vessel contained twenty-six pale eggs. Judging from the figures, the embryos, in external appearance, resemble to a remarkable degree those of *Hylodes martinicensis*. They are unpigmented and are bent around a large yolk-mass, 4 mm. in diameter. The head, which is large and flat, and the eyes may be seen through the egg-membrane. No traces of gills were discovered. The accounts vary as to the condition of the embryo when hatched. According to Goeldi ('95), frogs that hatched in confinement possessed both pairs of legs and small tails; the young jumped about actively and preferred not to stay in water. No details are recorded, but it is implied that the development is abridged and direct. Werner ('98) affirms that the tadpoles are ready to swim when hatched, and that the mother finds water to deposit them in. According to Fritz Müller's description in a letter to Darwin, the tadpole which he observed did not possess fore legs until two weeks after hatching; he saw no external branchiæ or opening that might lead to internal branchiæ.

Another mode of carrying eggs by the female frog is seen in the case of *Rhacophorus reticulatus* (*Polypedates reticulatus*). A single specimen, which was captured at a high elevation in Ceylon, carried twenty-one ova adhering firmly to the abdomen. It is uncertain whether the frog was caught in water or on land, and nothing has been noted as to the development.

An interesting adaptation in a dry climate is recorded of a species of *Spea* (*hammondii?*) in western North America. The eggs are deposited in rain pools, which collect in the dry arroyas and in the low lands. The tadpoles acquire their legs

very early, and are soon able to escape from the muddy fluid; thus, by accelerated metamorphosis, the chances of succumbing because of drought are lessened.

Lythodites latrans, which lives in fissures of limestone precipices of western Texas, is also supposed to deposit its eggs in pools of rain water.

The eggs of *Phryniscus nigricans*, in Paraguay, are laid singly, in temporary pools in grassy ground. "The eggs and larvæ do not seem to differ in any great degree from those of Rana. There is, however, a very large yolk plug, which remains evident after the closure of the neural groove." The development is very rapid, and, within twenty-four hours after segmentation begins, the tadpoles are hatched and wriggling about. They are probably washed into deeper pools.

Another case of rapid development is that of *Paludicola fuscomaculata*, also found in Paraguay. It spawns in January in shallow pools, and the eggs float on the surface. They measure 1 mm., are unpigmented, and have very little yolk. The tadpoles hatch within eighteen to twenty-four hours after segmentation begins, and hang in the water from the floating froth. "Many of the processes of development are blurred and, as it were, hurried over. The external gills never reach a high state of development."

Eggs which are thought to develop like those of Paludicola are said by the natives of Paraguay to belong to the frog called by them "Po it," more scientifically *Eugystoma ovale*. Eggs and larvæ are found in froth in holes in the ground, beneath fallen tree trunks. The nests "were a most ingenious contrivance for collecting water and keeping the eggs and larvæ at least moist between the storms of the wet season. They were always found within the forest belts which lay on the highest ground." The larvæ "would exist for a very long time in a small quantity of water without increasing in size, but when removed to a tank they grew enormously and very soon left the water."

A curious indifference to water has been observed in the case of *Spea bombifrons*, near Market Lake, in Idaho. The tadpoles, still "in the free-swimming condition," but entirely

air-breathers, were seen quite out of reach of the water, in small spaces which they had cleared in the ground. The legs were full-grown, the tail undiminished, the jaws toothless and cartilaginous and "some quite larval in form."

Two species of Dendrobates resort to a device by which it is supposed that the young are transferred from one pool to another. The accounts are sometimes referred to as if they related to a single species. The species closely resemble each other, except in size; the larger, *Dendrobates trivittatus*,[1] is found in Dutch Guiana, the smaller, *Dendrobates braccatus*,[2] occurs in western Brazil. These frogs and *Phyllobates trinitatus* from Trinidad and Venezuela have the habit of carrying their tadpoles attached to the back, whether by suckers or by a viscid secretion from the parent, or by both, has not been determined. It has been observed in the case of *D. trivittatus* that the frog spawns in water, and that the free-swimming tadpoles attach themselves to the parent. They adhere firmly, since they were not brushed off when the parent was hotly pursued and crawled rapidly through the grass; the frog on this occasion was found far from water, and emerged from the grass and bushes freshly wet with rain.

D. braccatus is found on a table-land where, even in the wet season, the water may dry off in two or three days.

The tadpoles of both species possess the usual larval organs, including the horny mouth-parts. The intestine of the tadpole of *D. trivittatus* is said to be shorter and less coiled than in the ordinary tadpole, and to contain yolk.

In the case of Phyllobates it is the male frog that transports the young, but the sex of the frog is not recorded in either case of Dendrobates. The tadpoles of Phyllobates are ranoid, and the tail is about twice as long as the body; the anus is dextral, and the spiraculum sinistral.

[1] *Dendrobates trivittatus* has been wrongly called by one observer (Wyman, '59) *Hylodes lineatus*.

[2] Smith, in describing *Dendrobates braccatus*, reports that the natives of Brazil brought him from the Santarem forest a similar, though larger, frog and affirmed that, like *Dendrobates braccatus*, it transports its young. This may have been *Dendrobates trivittatus*, which is described by Wyman and others, since the difference between the two species is one of size.

A case which resembles Phyllobates and the like, superficially at least, has been discovered by Brauer ('98) in the Seychelles. *Arthroleptis seychellensis* inhabits a forest about 500 feet above the sea, where the streams are swift and there is no still water. The frogs are found in decayed trunks and among damp leaves on the ground, and on one occasion, late in August, a number of eggs were found under leaves from which the adult had been frightened away. The eggs were not included in a common gelatinous covering; they hatched in a glass, and the tadpoles immediately stuck to the glass by their abdomens. Tadpoles of about the same stage of development were also found adhering to the back and sides of an adult. The tadpoles had prominent eyes, mouth well under the anterior end of the head, short hind legs, fore legs concealed beneath an operculum, rudder tails more than twice as long as the body, and a large amount of yolk bulging out on either side of the body. No opening was found to the operculum, and no internal gills, nor were the rudiments of lungs discovered. The outer layer of epithelial cells on the abdomen was columnar, making the epithelium appreciably thicker there than elsewhere; gland cells were wanting on the abdomen only, though a slimy secretion covered the surface. An adult carrying older tadpoles was found at another time. Gland cells were present on the abdomens of these tadpoles; the anterior legs had come through the skin, the toes were found on all the feet, the length of the tail was not reduced in proportion to the body, and much yolk was still present. Rudiments of lungs were found, and the entodermic epithelium had differentiated from the yolk.

Brauer concludes that the eggs are covered with leaves by the parent (probably the male), that the young, when hatched, place themselves, with the assistance of their tails, on the parent's back, where they adhere partly by suction, partly by aid of the roughness of the parent's skin, and partly by a secretion, largely from the adult. Finally, the tadpoles are not attached to the parent for transportation to water, but undergo a large part of their development on its back.

Hylodes martinicensis has been described as the "coqui"

found on several of the islands of the West Indies. Superficial descriptions of the eggs are recorded by two writers (Bello, '71; Peters, '76). The eggs were found on damp leaves of plants, and near them was the female, apparently on guard. The frogs hatched in the adult form after fourteen days. The embryo is described as wrapped about the yolk, like a mammal. On the seventh or eighth day both pairs of legs were present, and the tail, eyes, and pulsating blood vessels were observed. On the twelfth the characteristic toes and suckers had appeared. The tail was turned downward, with the broad surface pressed against either the right or left side of the embryo. There was no trace of gills or gill-slits, but the tail was so fully supplied with blood that it was regarded, without doubt, as a breathing organ. On the fourteenth day newly hatched embryos were 5 mm. in length, and the tail, which measured about 1.8 mm., was absorbed during the course of the day.

In 1873 there appeared in several magazines various accounts, by Bavay, of a frog which he called *Hylodes martinicensis*. The accounts differ in some respects from those of the other observers of Hylodes, but are not altogether consistent among themselves, so that Bavay's observations were probably not very accurate. He affirms that in one locality, at least, spawning does not take place during the dry season, or even after lack of rain in the wet season; the eggs are always found in damp places, under stones or with decaying leaves. Instead of fourteen days, he allows only ten or eleven for hatching, and states that the frog goes through the usual metamorphosis within the egg. The eyes, legs, tail, and feet he describes at a period earlier than that in which they were found by the other observers, but in regard to the tail his own accounts vary; he stated at first that it disappeared two days before hatching, but afterwards announced in a published letter that he found a vestige of a tail in tadpoles just hatched, when they were hardened in glycerine. The vitellus, according to his observations, was at first connected with the embryo by a cord, for the embryo on the fourth day moved independently of the yolk-mass, although at the same time both

rotated together in the egg. On the sixth day the yolk was covered with a vascular network, and on the ninth it had been incorporated in the body. On the fourth day, when the embryo was turning actively, the heart was beating, and on either side of it there was a trace of a gill; a vein and artery were seen running parallel in the gill. In the course of the next few days the gills had first increased and become blood-red, then diminished, and on the seventh day only a red spot remained, which disappeared on the ninth. Bavay's observations were made in Guadeloupe, and it is possible that on this island there is a frog differing from *Hylodes martinicensis* in the points indicated by Bavay's description.

A study of two stages of the excretory system of Hylodes led Selenka ('82) to the opinion that the embryonic and permanent kidneys develop earlier than in the frog, producing a condition which approaches that of reptiles.

It would be interesting to know something of the development of *Hylella platycephala*, a frog which occurs in southern Mexico. It is said to lay its eggs in the axils of the leaves of Tillandsia, where the frog "undergoes its metamorphosis, high above the ground."[1]

Whether the entire development occurs within the egg-membrane, and whether water continually remains on the plant is not stated.

A short note on a frog, supposed to be *Hylodes lineatus*, records some evidence that its embryos undergo their entire development within the egg-membrane. The eggs have been found in Peru under grass far from water, and the embryo not yet hatched possessed no trace of a tail, but well-developed feet provided with suckers.

The young of *Rana opisthodon* hatch in the adult condition. Eggs were collected in crevices of rocks close to a stream on a peak of one of the Solomon Islands. The eggs measured from 6 to 10 mm. in diameter. In the younger stages the

[1] Andrews ('92) reports that the eggs of a tree frog in Jamaica have been found in the water at the bases of the leaves of epiphytic bromelias. They were observed in early stages of development, at the end of May, in the region of Mandeville.

embryo was folded around a large yolk-mass in the same way as *Hylodes martinicensis.* The tail was entirely wanting in the more advanced specimens. No traces of gills were found, but on each side of the body were several transverse folds of skin that were thought to be respiratory organs. The legs were well developed; the anterior were shorter than the posterior. The tip of the upper lip was furnished with a small conical protuberance, which in one case projected through the envelope of the egg, suggesting that its function is to perforate the egg-membrane.

The South African frog *Dactylethra capensis*, like *Pipa americana*, the other representative of the Aglossa, lives entirely in water; the tadpoles of the two forms agree in having the fore limbs free from the operculum and in having two spiraculæ.

Leslie ('90) writes of Dactylethra (called by him Xenopus): "Its habits are essentially aquatic, the animal never leaving the water except in search of places where food or shelter is better supplied. Unlike other frogs, it feeds in the water, on insects, small fishes, or even young and larvæ of its own kind, and is apparently unable to feed out of that element. The mode of eating is by forcing the prey into the mouth by means of the hands, which act as a pair of claspers; the deglutition always takes place under water. Locomotion on land is by difficult and awkward crawling and leaping. But Xenopus is a most admirable swimmer, and remarkable for the manner in which it remains poised for a long time immediately under the surface of the water, with the nostrils only exposed. The whole structure of the animal denotes its thoroughly aquatic habits — the broadly webbed toes, the smooth, slimy skin with its symmetrically disposed muciferous tubules; there are no eyelids proper, but merely the transparent nictitating membrane, moving up and down; and the nostrils have a disk-like internal valve. When at rest, Xenopus never assumes a sitting posture like other frogs and toads, and the back never appears humped."

The eggs (measuring about one-sixteenth inch in diameter) are laid singly and attached to water-plants or stones, each

surrounded by a mucilaginous covering. They are at first very slightly pigmented. Tadpoles in the Zoölogical Gardens in London hatched in about two days; the head of the newly hatched tadpole is broad and flat; the fin is developed on the tail to the posterior end, and there is no chimæroid lash as Parker ('77), and subsequently the text-books, have figured; the intestine is coiled as usual. The tadpoles in confinement had access to vegetable food, but subsisted entirely on an animal diet. A single ventral adhesive gland persists for a long time and at an early period occupies the whole ventral surface of the head. The buccal cavity is open to the exterior the day after hatching. No jaws or beak develop. A few days after hatching a pair of tentacles develop on either side at the angles of the jaw; one of them may become bifurcated and each is provided with two channels through which the blood streams. External gills are not wholly wanting (as was formerly thought), for two days after hatching, when the operculum is commencing as a free fold, there are vascular lamellæ on the first three branchial arches. The gill-slits open later than the mouth; the hyoid cleft opens last by a tube into the first branchial cleft, a long way from its opening to the exterior. At the same time that the gill-slits open, a tufted filtering apparatus is developed from the branchial arches; this becomes vascular and must, it is thought, be respiratory, as no internal gills develop. The opercular folds do not cover the arms, but open by a slit on each side, anterior to the arm. The spiraculæ persist for a long time. The pronephros develops as in the ordinary frog. The vascular system develops as described by Maurer for *Rana esculenta.*

It is evident from the foregoing review that many points in the embryology of the Anura remain to be investigated; it is not, however, surprising that the work has been left undone, when we consider the geographical, the climatic, and other difficulties attendant upon making observations and collecting material.

GERMANTOWN, PENN., 1900.

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APPENDIX I.

Since this paper went to press, there have appeared the following notes on Nototrema by Brandes, **'99**. "Larven zweier Nototrema-Arten. Demonstration." *Verhandlung der deutschen Zool. Ges., 9. Jahresvers.* Hamburg, p. 288.

The female of *Nototrema marsupiatum* carries a great number of small eggs (200). The full-grown larva has a rudder-tail with a well developed capillary network, hind legs in the condition of knobs, horny teeth, and an operculum with a lateral spiraculum. Through the spiraculum project two filaments, which can be traced to the first and second gill arches of the opposite side. The filaments are expanded at their ends into a delicate membrane, spread out under the egg-membrane. The gills are thus reduced to two, both arising from the same side. In the larva examined, the yolk had been entirely absorbed, so that life in the egg-membrane was no longer possible. A larva caught in water resembled a tadpole of the European Pelobates shortly before metamorphosis.

Nototrema oviferum carries only thirty large eggs. The tadpoles observed had well developed hind legs; the tails had entirely degenerated; there was no spiraculum, but through a broad slit in the operculum projected the two bell-gills described by Weinland (**'54a**). Four gill arches were present, and the gill filaments were attached to the first and second arches.

APPENDIX II.

Index to species, with a summary of references to each.

Alytes obstetricans. Europe.
Demours, 1741. Wagler, '33. Vogt, '42. Steenstrup, '46. Claus, '66. De l'Isle, '76. Leydig, '77. Gasser, '82. Hartmann, '96. Wyman, '59. Nature, '77. Bronn, '78. Knauer, '78. Cope, '85. Sarasin, '87. Boulenger, '86a. *Ib.*, '98. Werner, '98. Page **696**.

Amphignathodon guentheri. Tropical Andes.
Cope, '85. Page **700**.

Arthroleptis seychellensis. Seychelles.
Brauer, '98. Page **704**.

Chiromantis guiniensis (*C. refuscens*). West Africa.
Peters, '75. *Ib.*, '76 (plate). Ihering, '86. Nature, '77. Bronn, '78. Cope, '85. Sarasin, '87. Boulenger, '86a. Werner, '98. Page **689**.

Cystignathus gracilis (*Paludicola gracilis*). d'Orbigny, '47. Hensel, '67b. Sarasin, '87. Boulenger, '86a. Brazil, Argentine Republic. Page **691**.

Cystignathus mystaceus. Rio Grande do Sul.
Hensel, '67a. *Ib.*, '67b. Nature, '77. Knauer, '78. Bronn, '78. Sarasin, '87. Boulenger, '86a. Page **692**.

Cystignathus typhonius. Porto Rico.
Peters, '76. Page **692**.

Dactylethra capensis (*Xenopus lævis*). Southern Africa.
Wyman, '62. Gray, '64a. *Ib.*, '64b. Parker, '77. Boulenger, '81. Leslie, '90. Beddard, '94. Page **707**.

Dendrobates braccatus. West Brazil.
Smith, '87. Cope, '87. Boulenger, '88a. *Ib.*, '88c. *Ib.*, '95. (Boulenger refers indiscriminately to Kappler, '85, and to Smith, '87, and Cope, '87, although these authors have described two species, which Cope says differ in size.) Cope, '89. Werner, '98. Page **703**.

Dendrobates trivittatus. Dutch Guiana.
Wyman, '57. *Ib.*, '59 (under the name of *Hylodes lineatus*). Kappler, '85. Boulenger, '88a. *Ib.*, '88c. *Ib.*, '95. Smith, '87 (in which mention is made of a frog from the Santarem forest, which is perhaps *Dendrobates trivittatus*). Werner, '98. Page **703**.

Engystoma ovale. Paraguay.
Budgett, '99. Page **702**.

Hyla abbreviata (*Ololygon abbreviatus*). Rio Grande do Sul.
Hensel, '67a. Knauer, '78. Page **693**.

Hyla faber. Rio de Janeiro. (Early accounts under the name of *Cystignathus ocellatus.* Rio Grande do Sul.)
Hensel, '67a. *Ib.*, '67b. Goeldi, '95. Bronn, '78. Knauer, '78. Boulenger, '86a. Schönichen, '97. Page **692**.

Hyla goeldii. Rio de Janeiro.
Fritz Müller, '79. Goeldi, '95. Boulenger, '95. Werner, '98. Page **701**.

Hyla nebulosa. Rio de Janeiro.
Goeldi, '95. Page **691**.

Hylella platycephala. Southern Mexico.
Cope, '85. Page **706**.

Hylodes lineatus (?). Peru.
Wolterstorff, '90. Page **706**.

Hylodes martinicensis. West Indies.
Steenstrup, '46. Bello, '71. Bavay, '73a to e. Peters, '76. Selenka, '82. Andrews, '92. Nature, '77. Bronn, '78. Cope, '85. Sarasin, '87. Boulenger, '86a. Page **704**.

Lythodites latrans. Western Texas.
Cope, '85. Page **702**.

Nototrema fissipes. Brazil.
Boulenger, '88b. Page **699**.

Nototrema marsupiatum. Ecuador, Peru.
Boulenger, '80. Weinland, '54a. Nature, '77. Cope, '85. Sarasin, '87. Boulenger, '86a. Page **700**.

Nototrema oviferum (*Notodelphys oviferum. Opisthodelphys oviferum*). Venezuela.
Weinland, '54a. *Ib.*, '54b. Berthold, '56. Wyman, '57. *Ib.*, '59. Owen, '66. De l'Isle, '76. Nature, '77. Bronn, '78. Boulenger, '82. Cope, '85. Howes, '88. Sarasin, '87. Boulenger, '86a. Page **698**.

Nototrema plumbeum.
Werner, '98. Page **700**.

Nototrema pygmæum. Puerto Cabella, Venezuela.
Werner, '98. Page **700**.

Nototrema testitudineum. Ecuador. Peru.
Boulenger, '82. Cope, '85. Sarasin, '87. Boulenger, '86a. Page **700**.

Paludicola fuscomaculata. Paraguay.
Budgett, '99. Page **702**.

Phryniscus nigricans. Paraguay.
Budgett, '99. Page **702**.

Phyllobates trinitatus. Trinidad. Venezuela.
Boulenger, '95. Werner, '98. Page **703**.

Phyllomedusa hypochondrialis. Paraguay.
Budgett, '99. Page **690**.

Phyllomedusa iheringii. Rio Grande.
Ihering, '86. Knauer, '78. Howes, '88. Sarasin, '87. Goeldi, '95. Werner, '98. Page **690**.

Pipa americana. British and Dutch Guiana.
Fermin, 1765a. *Ib.*, 1765b. Laurenti, 1768. Göze, 1776. Spallanzani, 1785. Camper, 1788. Wyman, '54a. *Ib.*, '54b. Parker, '77. Wilder, '77. Sclater, '95. Leydig, '96. Bartlett, '96. Duméril et Bibron, '54. Wyman, '57. Peters, '76. Nature, '77. Knauer, '78. Bronn, '78. Boulenger, '86a. Schönichen, '97. Werner, '98. Page **693**.

Polypedates maculatus. Ceylon.
Gunther, '76. Ferguson, '76. Sarasin, '87. Page **693**.

Rana opisthodon. Solomon Islands.
Boulenger, '86b. Sarasin, '87. Boulenger, '86a. Page **706**.

Rana temporalis. Ceylon.
Sarasin, '87. Page **693**.

Rhacophorus eques. Ceylon.
Sarasin, '87. Page **691**.

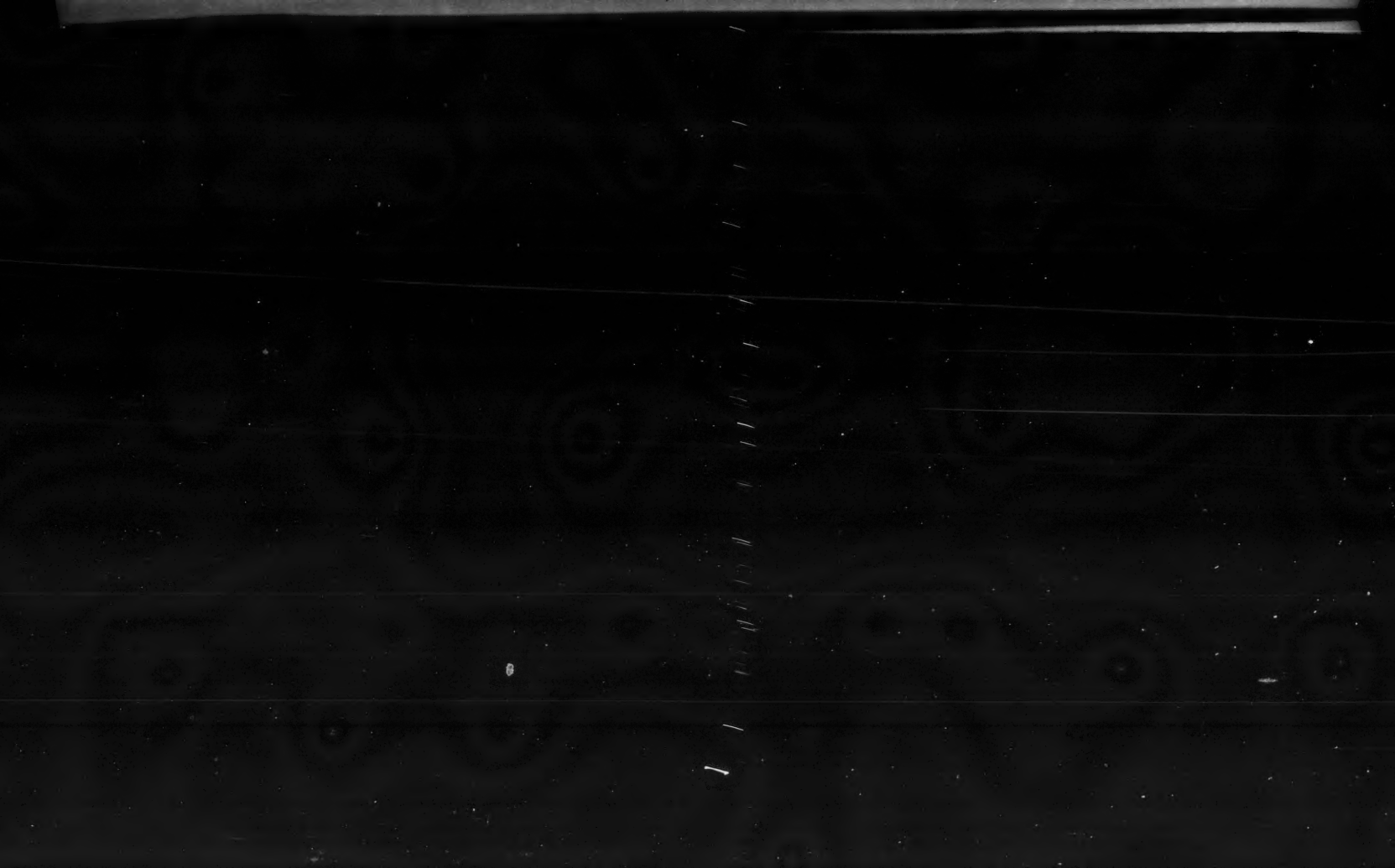
Rhacophorus reticulatus (*Polypedates reticulatus*). Ceylon.
Günther, '76. Ferguson, '76. Bronn, '78. Boulenger, '86a. Page **701**.

Rhacophorus schlegelii. Japan.
Holland, '89. Ikeda, '97. Werner, '98. Page **689**.

Rhinoderma darwinii. Chile.
Gay, '36. Espada, '72. Spengel, '77. Howes, '88. Bronn, '78. Boulenger, '86a. Plate, '97. Werner, '98. Page **700**.

Spea bombifrons. Idaho.
Cope, '85. Page **702**.

Spea hammondii. Western North America.
Cope, '85. Page **701**.



ON THE INTESTINE OF AMIA CALVA.

WILLIAM A. HILTON.

ALTHOUGH much work has been done upon the morphology and embryology of Amia, but little attention has been given to the microscopic anatomy of the intestine. After an examination of sections of Amia's intestine, and after comparing them with what has been done on the subject, it was found that there were many interesting but rather difficult problems which remained to be solved. In consideration of some of these points a more careful investigation was undertaken.[1]

In order to obtain a clear idea of the form of the mucosal convolutions, specimens were examined which had been injected with and preserved in either formalin or alcohol. For injecting the capillaries the "Berlin blue injection mass" was used. The body was transsected caudad of the vent, and the injection made into the dorsal aorta within the hæmal arch. In making preparations to show cellular structures the usual histological fixers and stains were used; such fixers as Flemming's, Hermann's, Zenker's fluids and mercuric chloride solution ; such stains as safranin, iron-hæmatoxylin and chloral hæmatoxylin, with picro-fuchsin.

The gross structure of Amia's intestine has been carefully described elsewhere (Hopkins, '92), so a simple description is all that is necessary to give here. The stomach lies parallel to the cephalic part of the intestine and joins it at a very acute angle; the pyloric valve marks the junction of the two parts and appears on the exterior as a very deep constriction. Internally, the pyloric valve projects as a tube a short distance into the cavity. The first part of the intestine is quite long and extends in a parallel line for about two-thirds the length of

[1] The work was done in the histological laboratory of Cornell University. I wish especially to thank Professors Wilder, Gage, and Kingsbury for their valuable suggestions relating to the investigation.

the abdominal cavity. After the first turn the intestine is of considerably less diameter than that of the first part. This second part, after quite an acute angle with the first part, ascends parallel with it for from one-third to one-half of its length, and then, after a very sharp turn, descends once more. After a few centimeters of descent the intestine bulges out to a large diameter, indicating the location of the spiral valve; as it approaches the vent, the spiral valve having ended, the intestine once more becomes of small diameter. The spiral valve, which occupies a few centimeters of extent above the end of the rectum, has from four to four and one-half turns (Hopkins, '95).

Before taking up the finer structure of the intestine, the general form and arrangement of the mucosal convolutions will be considered. In this part of the study it was found that the character of the convolutions was much more easily and accurately made out from gross preparations than from sections, for, although serial sections may show much, a clear comprehension of all the complications can be obtained only by examination of the whole ental surface of the intestine. The following description is largely taken from a single specimen, one having been selected in which the most characteristic condition was presented. Upon a superficial examination of the intestine, slightly distended, the whole ental surface appears to be covered with villi thickly and irregularly placed, varying somewhat in height, but less in general shape, at different parts of the intestine. These appearances are to some extent deceptive; the upper part of the intestine is covered with a network of long and short zigzag folds and isolated villi. The folds run in every direction, and their free edges are more or less irregularly but deeply notched or wavy. Some of the projections or villi are perfectly isolated; others, which at first sight seem to be perfectly free, are found on more careful examination to have connection with their neighbors at the bases. There are all gradations, from perfectly isolated villi to irregular, short, zigzag folds. Many folds or nearly perfect villi join each other throughout their whole height; others slightly at their bases. All are of irregular, undulating heights. Many folds are several centimeters in extent, so that a very complicated

appearance is presented. Between and about the network with the few isolated villi, which altogether form a rather loose meshwork, are much lower and much smaller villi or folds. These are not easily seen, because of the overshadowing higher folds and villi, and, in some specimens, seem to be altogether absent. Some of these lower, smaller folds are joined to the higher ones.

In one of the intestines examined there were, in one or two instances, clumps of folds in very close contact, almost cemented together in one mass; in other places the folds in little groups were in close contact when the intestine was not especially distended, but these, unlike the case just cited, could be separated from each other without tearing. In many cases folds are joined together in the form of a small ring or rather large crypt, not completely closed on one side; but in at least one case a complete ring or crypt was formed by the folds. There are comparatively few projections or villi which are completely separated from all about them, although in many cases the place where they unite with others may be of so little extent that it is easily overlooked.

The tendency of the folds, as well as the arrangement of the larger villi, seems to be fully as great toward a transverse as to a longitudinal direction. The higher villi begin at the pylorus with a height of about .8 mm., and at about the central portion or last portion of the first part of the intestine a height of about 3.5 mm. to 3.8 mm. may be reached; after this the folds and villi become gradually shorter caudad.

Nearer the pylorus folds can be more easily made out than a short distance below, because at first the folds are not so deeply indented on the free edges as farther down; they are also more numerous near the pylorus, that is, less split up into villi. With that part of the intestine a little above the first turn, the folds are more of them deeply split, and there are also numerous large villi, such as 3 mm. long by 1.2 mm. broad. The thickness of the folds and villi is about .2 mm., being in shape thin, plate-like, or leaf-like.

Below the first turn the folds are lower and appear a little more evenly placed, forming more of a continuous network of

rather square meshes than was the case cephalad. Their free edges also seem to be less jagged, but, like those cephalad, they have wavy, free edges, and between the higher convolutions there are lower ones somewhat connected with the larger ones or free. There are comparatively few large, free projections or villi in this region.

At the beginning of the second turn the regular network appearance is usually lost, and the projections shorter, more irregular, and more jagged. After the most cephalic face of the spiral valve is passed, there are a few long, straight folds which appear to run in a longitudinal direction when the intestine is cut open lengthwise and slightly distended. Most of the other folds of the spiral valve might almost be considered to be villi, with rather broad bases and sharp tips. Below the spiral valve the convolutions are usually almost all longitudinally disposed; there are quite a number of low projections nearly free from each other, having rounded edges and arranged in parallel lines, almost like villi, but usually joined to each other by their bases.

The above description applies especially to medium-sized or rather large specimens, many points being obscure in smaller individuals, partly because of the smaller size of the convolutions, and partly because of individual variations. Aside from the usual variations which occur in all specimens without any special rule, there is a way in which large specimens differ from small in quite a constant manner; that is, the difference in the height of the convolutions, the larger individuals usually having longer projections than the smaller. This difference is rather a general one with the villi of many mammals and birds.

The muscular coats of the intestine are, as in all vertebrates, an outer longitudinal and an inner circular. The longitudinal coat is rather thin and made up of small, more or less irregular, bundles of plain muscle. The circular layer of muscle is enormously developed and, for most of its extent, seems to be of about the same thickness. There is but scant connective tissue about the bundles which make up the inner coat, while the connective tissue about the smaller bundles of the longitudinal coat is well developed. These muscular coats vary but little

until the most caudal portion of the intestine is reached, and then, gradually, the muscle of the outer coat becomes less prominent, and at the end of the intestine the outside coat is made up of simply a thick band of connective tissue, with a very few small muscle bundles. There are so few of these that it does not seem that they have a very great part to play in the contraction of the intestine. The inner muscular coat undergoes no such decrease in size at the end of the intestine, but it does undergo some change, and at the last of the intestinal canal there is quite a marked decrease in the thickness of the coat, and the muscle fibres are not completely circularly arranged, as in the rest of the intestine; but a rather complex arrangement of the muscle fibres has taken place, which differs much from the perfectly circular layer of fibres in the other places (Fig. 8). Perhaps this complicated arrangement is partly to compensate for the diminished longitudinal coat and also to take on some new functions, such as some of the muscles of the rectum perform in higher animals.

Just entad of the inner muscular coat is a thick layer of connective tissue composed of fibres longitudinally disposed. This band of connective tissue is about as thick as, or somewhat thicker than, the outside muscular coat and very dense. It does not seem to vary throughout the intestine, except at the end, where it gives place to a dense mass of connective tissue and isolated clumps of plain muscle bundles. At this place the mass of muscle and connective tissue extends uniformly from the epithelium to the inner muscular coat. It is about as thick as the two muscular coats together. With this exception the band of connective tissue is uniform throughout the intestine. It might be considered as an outside layer of submucosa, a sort of base upon which all the rest of the submucosa and mucosa rest. A dense connective-tissue band lying directly inside the muscular coats, but not so close to them as in Amia, has been described for several forms, as in the trout and *Tinca vulgaris;* this membrane has been called the *membrana compacta* or *stratum compactum.* Doubtless the connective-tissue layer in Amia is homologous to this *membrana compacta.*

Especially above the spiral valve connective-tissue strands

from the *membrana compacta* extend to the tips of the folds and villi.

In the upper intestine the submucosa is rather thin, and but a scant *muscularis mucosa* exists. In the region of the spiral valve the submucosa above the *stratum compactum* is a little thicker, and a prominent *muscularis mucosa* is present, lying in a rather dense mass. There are in many places rather isolated muscle fibres of the *muscularis mucosa* going up into the villi, and the connective-tissue prolongations so characteristic of the upper intestine are not nearly so marked. The muscle fibres of the villi extend upwards longitudinally, and were, without doubt, derived from the *muscularis mucosa*, as in mammals and birds. At the very end of the intestine, where folds and villi usually cease, there is an abundant *muscularis mucosa*, there being many longitudinal, and possibly a few transverse, muscle fibres and bundles of fibres scattered irregularly through all the dense connective tissue between the epithelium and muscular coats.

In general, the cores of the villi and folds, also all the submucosa above the *stratum compactum*, are composed of rather dense adenoid connective tissue. There are no lymphatic glands or patches of adenoid tissue anywhere in the intestine, but there are in many places areas of diffuse adenoid tissue, especially in the lower part of the intestine.

Before leaving the submucous structures to go on with those of the epithelium, it may be well to speak of the elements composing the spiral valve. Macallum ('86) states that in the spiral axis of Acipenser and Amia there is a large quantity of unstriated muscular fibres, which in Amia is aggregated into a single bundle. In Acipenser he states that there are several bundles arranged irregularly in direction and position, so it is almost impossible to conceive that they represent excessively developed portions of the *muscularis mucosæ*. In Amia, although sections at times seem to show nearly a uniform bundle of muscle fibres occupying the central part of the valve, other and most of the sections show clearly numerous more or less closely placed bundles of plain muscle, most of the fibres running transversely, that is, nearly parallel with the free edges

of the valve. Comparatively few run in the other direction. The *muscularis mucosa* at the base of the spiral valve is not especially thickened or diminished; it occupies its usual position on the ental side of the *stratum compactum*. The connective-tissue layer of the *stratum compactum* on each side of a turn of the spiral is seen in section to send upward into the spiral valve a thick portion of connective tissue; on the ental surface of each of these portions is the usual *muscularis mucosa*. These two layers meet in the basal part of the valve to form a sort of arch. Beneath the arch thus formed are muscle fibres composing one large bundle or several small bundles. It may be seen that in this way muscle and connective tissue are considerably mixed up in the basal part of the valve; but farther entad all become arranged once more, the muscle occupying the center of the valve, while on each side of it, between it and the submucosa, is a rather dense band of connective tissue; these bands, however, are not so dense as to prevent muscle fibres from going up into the villi (Fig. 9).

Three conclusions are to be drawn from the above complicated condition. First, the relative position of muscle and connective tissue is somewhat different from that in the intestine in general. Secondly, the core and, in fact, a large part of the spiral valve are made up of muscular tissue. Thirdly, there is more muscle in the spiral valve than the double thickness of the *muscularis mucosa*, and although a small part of the muscle is derived from the *muscularis mucosa*, by far the larger part is not.

The intestinal epithelium of Amia presents a very interesting condition. The cells are exceedingly small, and in most places it is impossible to make out in sections the cell outlines. Macallum ('86) describes the epithelium to be composed of short cylinder cells resting on four layers of nuclei. This is often the appearance presented in sections; sometimes there seem to be six or eight layers of nuclei, especially in the upper part of the intestine; possibly, at times, a few of these nuclei may be those of underlying cells. Macallum figures the nuclei in even layers; this is seldom the case, the nuclei seeming to be scattered irregularly through the epithelium. They are

usually somewhat elliptical, but may be irregularly circular. Isolated preparations from the epithelium are of the utmost value in determining the character and relation of cells. For isolating, Ranvier's dissociator of one-third alcohol was found to be especially good. The isolated cells were of the same length as the thickness of the epithelium, as shown in sections, the cell bodies being usually thin or even thread-like, with nuclei at all levels, thus showing with the greatest clearness that, although somewhat modified, the cells form a simple columnar epithelium. There might have been a few interposed cells at the bases of the longer ones, but if so they were not recognized. Usually, beneath the striated border of the cells is a band which takes a darker stain than the rest of the cell body. This was especially true of the epithelium towards the pylorus.

Although essentially similar in all parts of the intestine, the epithelium is especially thicker in the cephalic portion, there being in this first region a more complicated arrangement of nuclei at different levels. From the spiral valve caudad it is somewhat simpler, that is, it is not so thick, and the outlines of the cells are much easier to trace, there being at most but four layers of nuclei. Compared with the height of the epithelium of the lower intestine, there is greater distance from the surface to where the nuclei are located than is the case in the upper intestine. Goblet cells occur throughout the intestine, being more numerous caudad. In depth the thecas of the goblet cells occupy but a small proportion of the thickness of the epithelium or of the lengths of the cells of which they are parts. This is especially true of the upper part of the intestine.

Macallum ('86) describes cilia throughout the intestine of Amia. Comparing Macallum's statements with sections, in many places cilia seemed to be present, but careful examination of fresh specimens did not bear out these observations. In these experiments, as a check, living cilia were obtained from the œsophagus. Hopkins ('93) describes cilia in a very small area just caudad of the spiral valve; this is the only place in the intestine of Amia where true cilia occur; what

appear to be cilia in other parts are simply the striated border of the epithelium. This border is best marked above the spiral valve; it becomes narrower as the caudad end of the intestine is reached.

The blood of the folds and villi in Amia is supplied by a capillary network which resembles the blood supply of the villi in higher forms. Large blood vessels run in the submucosa and send up branches into the folds and villi. With a villus there are usually three main trunks of arterioles going up into a fine capillary network. When the projections join each other, there are numerous small blood vessels which connect, to a greater or less extent, the two almost distinct capillary systems. The blood supply of the more distinct folds is practically the same as that of the villi—a continuous network, usually supplied by about as many main trunks as if a number of villi occupied the same position.

It will be seen from some of the preceding structures described that a very interesting condition exists in the form and structure of the enteric convolutions. The intestine of Amia presents an appearance midway between folds and villi, having some of both structures, the latter, in a way, developed from the former by unequal growth. The villi possess all the characteristic structures of villi of mammals and birds, as do the folds, but falling short of villi simply because of their extent or lack of separation. In some of the higher forms, to a limited extent, signs of a transition from folds to villi are found, as in the double projections which occur occasionally in the small intestines of rabbits.

Villi have been described in a few species of Pices, but their presence is not usual in this class. However, it may be noted that in general the forms in which villi have been described are what are generally regarded as the higher teleosts. As villi are characteristic of the highest vertebrates, such as mammals and birds, it is not difficult to accommodate villi to the highest fishes. But how are we to account for the specialized condition of the intestine of Amia? Simply as follows: Amia is a very ancient form of vertebrate, one that has changed but little from the ancestral type, and, therefore, has had as a

species a long time for specialization, so the intestine has, during at least part of this time, become highly specialized, probably to suit more exactly the character of its food.

Another interesting point about Amia is the fact that in the spiral valve there is more muscular tissue than could have been derived from the *muscularis mucosa*. How did it get there? The answer to this question can be solved definitely only from the standpoint of embryology, but perhaps a suggestion may not be out of place. If the spiral valve was originally, if not in Amia in its progenitors, formed by a twisting of the whole thickness of the intestine, then a folding of the whole wall would, of course, involve the muscular coats as well as the submucosa and mucosa. In such a case muscle would be left in the spiral valve after readjustment of the outside coats once more to their usual appearance. Muscle from the *muscularis mucosa* would also be in the spiral valve, but the greater part would be from the muscular coats, and, because of the thickness of the inner muscular coat, the larger part of the muscle would run transversely, as is actually the case in the spiral valve of the adult.

GENERAL CONCLUSIONS.

1. The intestinal convolutions are very complex in form and arrangement, being made up of variously shaped folds and free projections or villi.

2. The muscular coats are well developed, an outer longitudinal and inner circular, the latter very thick.

3. A thick connective-tissue band, of uniform nature throughout the intestine, occurs next the inner muscular coat. This band of connective tissue sends up projections of fibres into some folds and villi.

4. A *muscularis mucosa* is present, a few fibres of which are prolonged into the cores of folds and villi.

5. The epithelium is simple, columnar, four to eight layers of nuclei appearing in sections.

6. The epithelium is not ciliated, except for a small area caudad of the spiral valve.

7. The blood supply of the folds and villi is similar to that of the villi of mammals.

8. True villi and partially developed villi occur.

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EXPLANATION OF PLATE I.

FIG. 1. Intestine of medium-sized *Amia calva; st.*, stomach; *py.v.*, pyloric valve; 1, first turn of the intestine; 2, second turn of the intestine; *sp.v.*, region of the spiral valve; *r.*, rectum.

FIG. 2. Folds and small villi of intestine near the pylorus; *f.*, fold; *v.*, villus.

FIG. 3. Intestine below first turn showing the ental surface; *f.*, fold; *v.*, villus.

FIG. 4. Last three faces of the spiral valve split lengthwise and distended, showing longitudinal folds on the spiral valve; *f.*, fold; 2, second face of valve; 3, third face of valve; 4, fourth face of valve; *w.*, intestinal wall.

FIG. 5. Folds near the end of intestine.

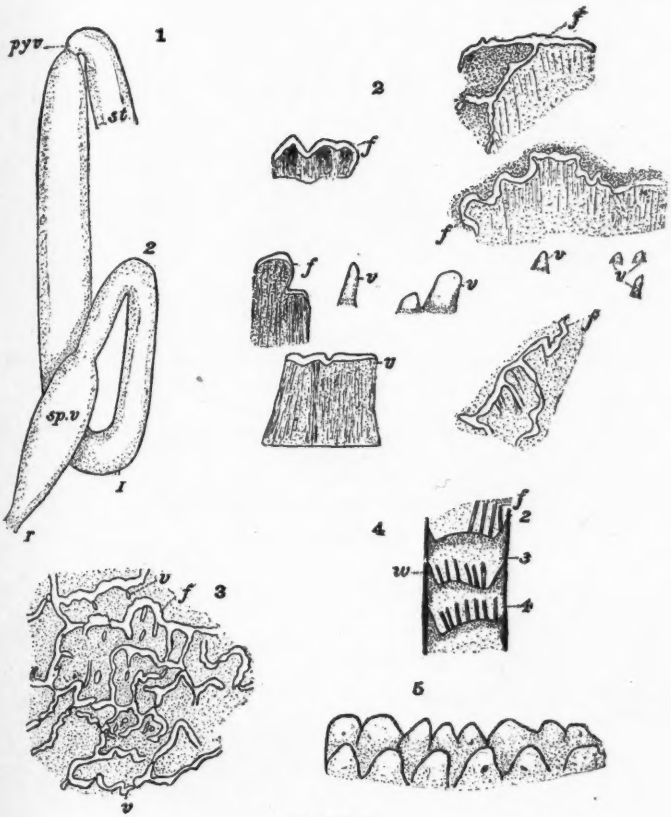

PLATE I.

EXPLANATION OF PLATE II.

E., epithelium; *c.*, cores of folds and villi; *ct.*, connective-tissue prolongations from the *stratum compactum* (*m.*); *im.*, inner muscular coat; *om.*, outer muscular coat; *lm.*, lateral muscular bundles; *tm.*, transverse muscular bundles; *mb.*, muscle bundles; *mm.*, *muscularis mucosa*.

FIG. 6. Sections of the intestine near the pylorus, moderate magnification.

FIG. 7. Section of intestine below spiral valve.

FIG. 8. Section of the end of intestine.

FIG. 9. Transsection of spiral valve, not showing epithelium.

(All figures × 37.)

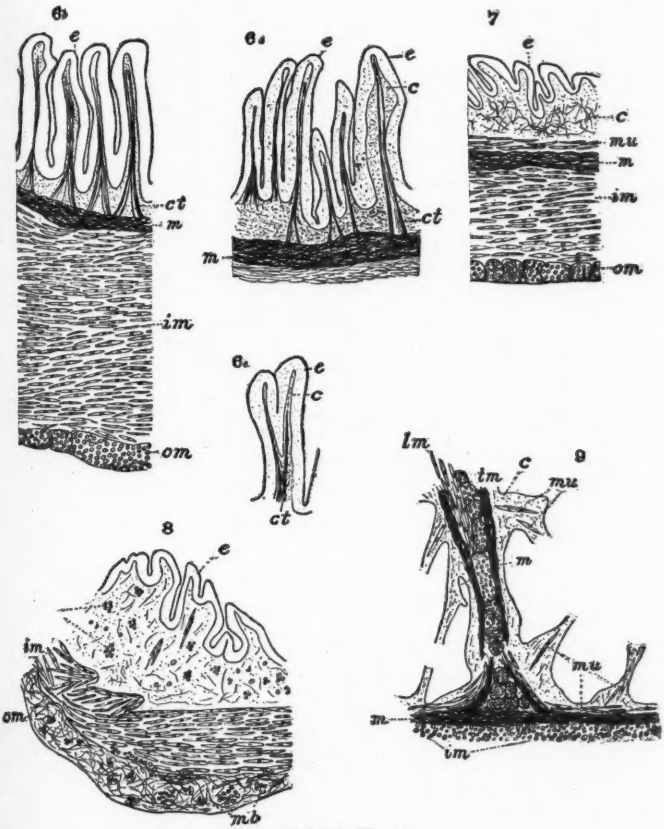
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PLATE II.

EXPLANATION OF PLATE III.

Epithelium under 1/12 in. oil immersion objective; *s.*, striated border; *n.*, nucleus; *g.*, goblet cell; *c.*, cell body.

FIG. 10 (a), (b), (c). Sections of epithelium from the first part of the intestine.

FIG. 11. Section of epithelium from the spiral valve.

FIG. 12. Section of epithelium near caudal end of the intestine.

FIG. 13. Isolated epithelial cells showing nuclei at all levels.

(All figures × 350).

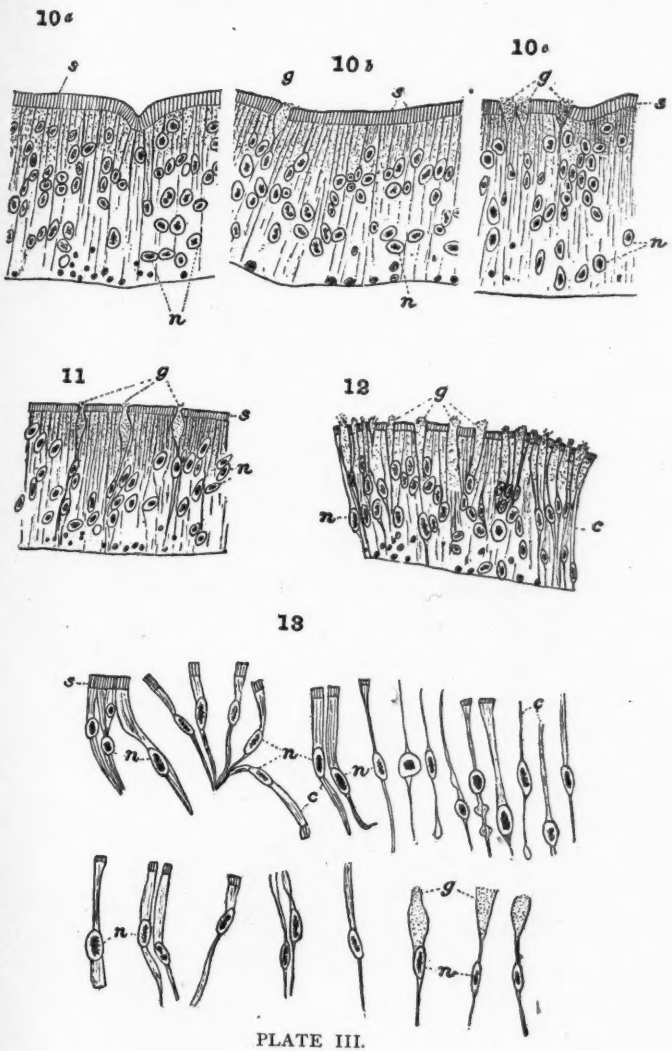


PLATE III.

EXPLANATION OF PLATE IV.

Injected folds and villi, cores of villi alone represented, except in Fig. 19.

FIG. 14. Villus near the pylorus. × 70.

FIG. 15. Villi below the spiral valve. × 70.

FIG. 16. Villus or part of fold on the spiral valve. × 70.

FIG. 17. Villus or part of fold below the pylorus. × 70.

FIGS. 18, 19. Folds from near the pylorus less highly magnified than the above, showing the usual main arterioles with the network of capillaries, and also that the network in these cases is continuous. × 39.

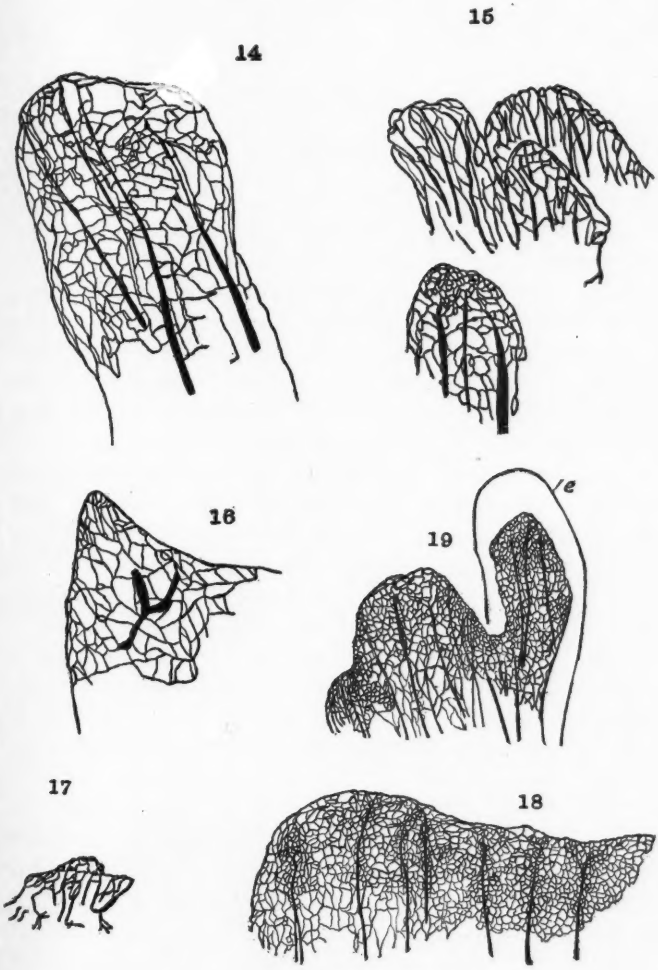


PLATE IV.

STUDIES IN CRANIAL VARIATION.

FRANK RUSSELL.

THERE are a number of characters of infrequent occurrence in the human cranium that are said to have considerable importance as criteria of race. The morphological significance of some of them is not yet known. The present study is almost wholly statistical; it has been carried out upon a collection of Amerindian crania which are not so well known as those of Old World peoples. Nearly two thousand skulls in the Peabody Museum at Harvard University were examined. Many of these are in a fragmentary condition, so that the number available for the study of one character may be very different from that of another, *e.g.*, statistics relating to the metopic suture may be tabulated when the frontal bone alone is present, but those relating to the hard palate can be reckoned only upon skulls that are nearly complete.

Metopic Suture. — The median frontal suture (Fig. 1) closes normally in the infantile skull during the second year. It remains open throughout life, however, in a certain number of cases that is fairly constant for each of the main divisions of mankind. This percentage of open metopic suture varies widely in the different groups, as, for example, between Europeans (8.7 per cent) and Australians (1 per cent). The morphology of metopic crania has been exhaustively treated by Dr. Papillault,[1] who has shown that they are higher and broader, in a word have greater capacity than the normal. The percentage of occurrence of the metopic suture in the adult crania of the Peabody Museum collection is seen in the table on the following page.

Tympanic Exostoses. — There is a tendency in all races toward the formation of bony tumors or exostoses in the

[1] Papillault, Dr. G. La suture métopique, etc., *Mém. Soc. d'Anth.*, T. ii, Sér. 3, fas. 1.

	NUMBER.	PERCENTAGE.
Eskimos	52	0
New England	68	2.9
Ohio and Tennessee	681	.8
California	160	1.9
Miscellaneous[1]	260	0
North America	1127	1.1
Peru[2]	458	1.1
Total[3]	1585	1.1

	NUMBER.	PERCENTAGE.	
"Peruvians"	565	3.5	(Anutchin)[4]
Amerinds	426	1.2	"
"	416	.7	(Harrison Allen)[5]

external auditory meatus. The tendency is increased in deformed crania, though it is now believed that such exostoses are not a necessary accompaniment of deformation; in support of this it will be noted that the small series of crania from New Mexico with pronounced occipital deformation exhibit not a single case of tympanic exostosis. I was somewhat surprised to find this condition of more frequent occurrence in the skulls from Ohio and Tennessee (Fig. 2) than in the deformed crania from Peru (Fig. 3). The exostoses varied in size from minute nodules to large tumorous growths and, in several

[1] Including small collections from the Northwest, New York, New Jersey, New Mexico, and the territory occupied by the plains tribes. In subsequent tables the term "miscellaneous" will be applied to the last two groups.

[2] The localities from which the Peruvian crania in the Peabody Museum have come are Ancon, Casma, Grand Chimu, Amacavilca.

[3] Compare the results obtained by Anutchin and Topinard in their investigations upon European crania:

Europeans of both sexes	10.7810 skulls	8.7	per cent metopic (Anutchin).
Catacombs of Paris	10.000 "	9.91	per cent " (Topinard in his *Éléments d'Anthropologie Générale*, p. 793).

[4] Anutchin, D. N. Reviewed by M. C. Merejowsky in *Rev. d'Anth.*, T. vi, Sér. 2, p. 360.

[5] Allen, Harrison. Crania from the Mounds of the St. John's River. *Journ. Acad. Nat. Sci.*, Philadelphia, New Series, vol. x, No. 4.

instances, to complete occlusion of the external auditory meatus. Dr. Whitney has called attention to the fact that when one lip only of the tympanic ring is affected, it is commonly the inferior.

Frontoparietal. — To economize space I have combined some of the characters in the tables; the somewhat rare anomaly known as the frontoparietal (Figs. 4, 5) may be placed here for convenience.

	Tympanic Exostoses.		Frontoparietal.	
	Number.	*Percentage.*	*Number.*	*Percentage of Occurrence.*
Eskimos	51	0	52	1.9
New England	64	0	64	0
Florida	58	5.2	57	0
Ohio and Tennessee	456	15.1	468	1.1
New Mexico	22	0	22	0
California	158	1.2	159	0
Miscellaneous	66	3.	62	1.6
Mexico	47	8.5	52	0
North America	865	9.2	884	.7
Peru (Ancon, Arica), etc.	447	5.4	449	.2
Total	1312	7.9	1333	.5

Parietal Foramina. — As these foramina are exceedingly variable, statistics relating to them, while difficult to procure, should be of considerable interest. Observations were made to determine whether any significance attached to their occurrence on the one side or the other, but as none appeared I have disregarded this in the table; "present" may mean on one side or on both. Owing to the fact that the foramina are frequently present, yet of extremely small size, and that the condition of many skulls obscures this character, it was found to be almost impossible to obtain accurate data. However, the table will be found to be very nearly correct. Enlarged foramina were discovered in only one group — three cases among crania from the aboriginal cemetery at Madisonville, Ohio.

Epactal Bone. — It is difficult to tabulate the variations occurring in the size and shape of supernumerary occipital

	NUMBER.	PERCENTAGE PRESENT.
Eskimos	52	61.5
New England	63	47.6
Florida	56	44.7
Ohio and Tennessee	515	50.3
New Mexico	21	61.9
California	158	67.1
Miscellaneous	61	54.1
Mexico	54	62.9
North America	928	53.8
Peru	447	70.3
Total	1375	59.2

bones. The true interparietal, the composite and incomplete epactals may be distinguished with tolerable certainty, but the smaller bones at the apex of the occipital are not so readily identified. Following Washington Matthews,[1] I have considered all Wormian bones at the lambda as falling in the class designated *os triquetrum seu apicis*.

	NUMBER.	PERCENTAGE.				
		Complete.	*Composite.*	*Incomplete.*	*Os quadratum.*	*Os triquetrum seu apicis.*
Eskimos	49	4.0	0	0	0	2.0
New England	66	3.0	0	0	0	0
Florida	62	4.9	1.6	0	0	11.7
Ohio and Tennessee	581	4.1	.9	.2	.5	3.1
New Mexico	21	0	0	0	0	0
California	159	1.9	0	0	1.2	4.7
Miscellaneous	69	0	2.8	0	0	13.0
Mexico	57	1.8	1.8	0	0	12.3
North America	1005	3.3	.9	.1	.5	13
Peru	451	1.8	1.8	.5	1.1	21.5
Total	1456	2.9	1.2	.3	.7	15

It will be observed that the complete or true interparietal bone occurs more frequently among North American tribes than among Peruvians. This is in harmony with the results

[1] The Human Bones in the Hemenway Collection, *Mem. Nat. Acad. Sci.*, vol. vi, p. 198.

obtained by Dr. Matthews from an examination of Cibolan (New Mexican) crania. Professor Boas informs me that some northwest coast tribes exhibit a high percentage of occipital anomalies. Compare Anutchin's[1] tables with the above.

	Number.	Complete.	Os Quadratum.
Amerinds "except Peruvians" . .	390	1.30	.26
"Peruvians"	664	5.46	1.05

As Anutchin's observations were made upon crania that were less uniformly deformed, they were probably in part of another tribe. This illustrates the desirability of abandoning the loose and unscientific term "Peruvians."

Platybasic Crania. — Occasionally a skull is found that has the occipital condyles and adjoining portions of the base thrust upward, as it were, into the cranial cavity. Presumably due to a greater or less degree of yielding of the floor of the calvaria to weight and muscular tension, it naturally occurs in all stages of development, according to the conditions. It is, therefore, difficult at times to distinguish between normal and platybasic crania; Topinard describes three varieties. Only well-marked examples are here noted. The results so far as they go seem to show that no relation exists between this condition and either cephalic index or artificial deformation. The highest percentage of occurrence is found among the Eskimos, who have the largest cranial capacity, but the number of skulls is too small to attach much significance to this.

Jugular Process. — The above table includes statistics concerning this somewhat rare anomaly, in which the process is enlarged until it extends beyond the plane of the condyles (Fig. 6). It is homologous with the paramastoid of the dog, etc. It occurs about once in one hundred crania from Peru and somewhat less frequently in North America.

Aymará Fossa. — Particular interest attaches to this character (Figs. 7, 8), owing to its supposed frequency of occurrence in the crania of criminals. As the fossa is very variable in

[1] *Rev. d'Anth.*, T. vi, Sér. 2, p. 143.

	PLATYBASIC CRANIA.		JUGULAR PROCESS.	
	Number.	*Percentage.*	*Number.*	*Percentage.*
Eskimos	49	6.1	48	2
New England	51	2	45	0
Florida	55	0	38	0
Ohio and Tennessee	477	.2	359	.5
New Mexico	21	0	21	4.8
California	158	.6	155	0
Miscellaneous	57	1.7	55	0
Mexico	52	0	48	2.1
North America	871	.5	721	.5
Peru	447	0	439	.9
Total	1318	.3	1160	.7

depth, care must be exercised, and it is practically impossible to wholly eliminate the "personal equation"; only cases in which an actual concavity exists are here noted. While it is of slightly more frequent occurrence among the crania from the coast of Peru than in those from the northern continent, it will be observed that it is by no means confined to southern tribes, as is shown by the high percentage among the Eskimos.

	AYMARÁ FOSSA.		FUSED ATLAS.		TORUS PALATINUS.	
	Number.	*Per-centage.*	*Number.*	*Per-centage.*	*Number.*	*Per-centage.*
Eskimos	49	10.2	48	0	43	18.6
New England	50	6	46	2	48	8.3
Florida	47	8.5	36	0	8	0
Ohio and Tennessee	425	3.7	358	.8	377	19.1
New Mexico	21	0	21	0	21	9.5
California	158	3.8	155	0	158	11.4
Miscellaneous	55	1.8	54	0	51	7.8
Mexico	47	6.4	47	0	42	4.7
North America	803	4.1	717	.6	704	14.4
Peru	437	5.9	438	.2	436	.2
Total	1240	4.8	1155	.4	—	—

Fused Atlas. — As might be expected, the Ohio-Tennessee collection contained several skulls having their condyles firmly joined with the atlas, sometimes resulting in the almost com-

plete absorption of the latter. Crania and skeletons from that region exhibit a large percentage of all kinds of malformations — atavistic, artificial, and pathological.

Torus Palatinus. — This hyperostosis of the middle line of the hard palate is most pronounced in the Eskimo crania. It was slightly more frequent in the Ohio collection (Fig. 9), though the ridges were not so large. With the exception of these two groups, this anomaly appears to be fairly uniformly distributed in North America. The number of skulls from Florida upon which this character could be noted is so small that it would be extremely hazardous to assume southern affinities for this group, because it resembles those of South America, where the percentage of occurrence of this anomaly is so low that I have not combined it with that of North America to form a total for the race. The Florida series also stands apart from all others studied in having a larger percentage of "pterion in K."

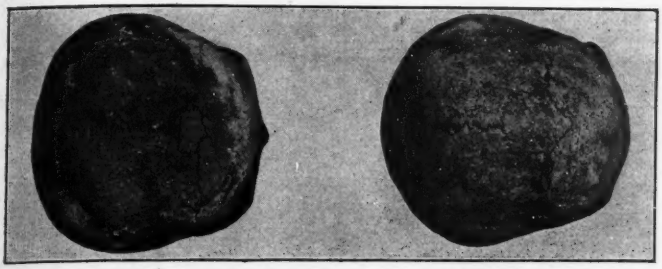
In addition to the above characters, observations were made to determine the percentage of occurrence of the infraorbital suture, right and left; of "pterion in H," etc.; as to whether the malar entered the spheno-maxillary suture; the number of bipartite malars (one case to the thousand skulls); and concerning the morphology of an anomalous process at the basion that was found three times in the whole collection. However, I have regarded these characters, somewhat arbitrarily perhaps, of less interest than those considered above and shall not publish the data relating to them.

I hope that the facts presented may prove suggestive and interesting, but do not expect them to establish firmly any hypotheses regarding the origin or affinities of the Amerinds.

1

2 3

FIG. 1 — Metopic suture. Grand Chimu, Peru. Cat. No. 480.
FIG. 2. — Tympanic exostoses. Ancon, Peru. Cat. No. 23,407.
FIG. 3. — Tympanic exostoses. Stone Grave, Nashville, Tennessee. Cat. No. 12,802.



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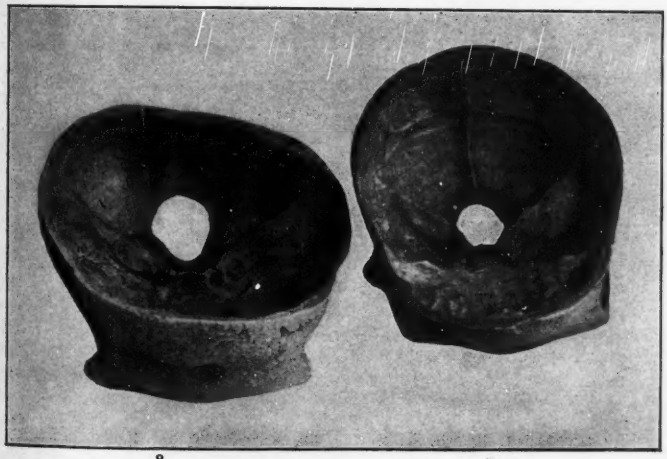

8 7

FIGS. 4, 5. — Frontoparietal. Stone Grave, Nashville, Tennessee. Cat. Nos. 2600, 17,314.
FIG. 6. — Jugular process. Lynville, Wisconsin. Cat. No. 11,252.
FIG. 7. — Interior of white skull, showing normal internal occipital crest.
FIG. 8. — *Aymará fossa*. Casma, Peru. Cat. No. 447.
FIG. 9. — *Torus palatinus*. Stone Grave, Nashville, Tennessee. Cat. No. 18,280.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XIII. The Actiniaria.

G. H. PARKER.

The Actiniaria, or sea anemones, are marine animals inhabiting the shallow and deeper waters of our coasts, and usually found attached to some rock or other firm object. They have been justly noted for their exquisite colors and forms. As a rule, each species is represented by separate individuals or *polyps*, but in the Zoantheæ (Fig. 22) colonies are formed by budding, much as in many corals. The sea anemones are further characterized by the fact that they produce no independent skeleton and that their tentacles are very usually simple or undivided. In the more typical species the polyp has the form of a short cylinder, the attached end of which is known as the *pedal disk*, the free end the *oral disk*, and the intermediate part the *column*.

The pedal disk is the organ of attachment for those species that are fixed and the chief organ for locomotion for those that move. It is usually well developed, but in species inhabiting muddy or sandy bottoms it is either reduced, as in Ammophilactis (Fig. 12), or entirely absent, as in the Edwardsiæ (Fig. 1) and the Ceriantheæ (Fig. 21).

The column is generally undivided, but in Halcampa (Fig. 3) as many as three parts can be distinguished: a pedal *physa* of small extent, an intermediate *scapus* corresponding to the column in the restricted sense, and an oral *capitulum*, which often suffers involution when the polyp contracts. The surface of the column is either smooth or more or less covered with eminences, known as *tubercles* (Figs. 9, 10). In the Sagartinæ (Fig. 17) the column wall is very usually pierced by pores, *cinclides*, through which water from the internal cavity of animal and

nettling filaments, *acontia*, may escape. The cinclides are sometimes borne on tubercles, which are then called *cinclidial tubercles*. In rare cases, as, for instance, Epiactis (Fig. 8), the eggs seem to be carried in pits on the column, and the young may be retained in these egg pits for a considerable period. The oral edge of the column is at times characterized by a series of enlargements that are probably neither tubercles nor tentacles, but have been called *marginal spherules*. Usually the oral edge of the column passes directly over into the tentacle-bearing portion of the oral disk. In some species, however, a fold is interpolated in this region, giving rise to what has been called a *collar*. The column, though usually strictly naked, may be covered with a slight secretion, *cuticula*, which may be firm and rough, as in Phellia, or slightly adhesive, so as to accumulate sand particles, as in Epizoanthus.

The oral disk carries the circle of *tentacles*. These are hollow processes from the wall of the disk and are usually pointed, though sometimes blunt or even club-shaped, as in Eloactis (Fig. 4). They are usually firmly attached to the oral disk, but in Bolocera (Fig. 6) the region of attachment is marked by a well-developed circular muscle, by whose contraction the base of the tentacle may be much constricted or even cut through, thus setting the tentacle free. As a rule, the tentacles cover a single circular area intermediate in position between the mouth and the margin of the oral disk. In Cerianthus (Fig. 21), however, they form two distinct bands, one *marginal* (principal) and the other *circumoral* (accessory). The *mouth* lies in the center of the oral disk and is generally surrounded by swollen lips. In Bicidium a portion of the lip is so much enlarged as to produce a projecting proboscis, the *conchula*.

Of the internal structure of the sea anemones little need be said in this connection, as the features upon which the following key is based are chiefly external. The mouth leads into a *gullet* or *œsophagus*, which opens at its pedal end into the one internal cavity possessed by the animal, the *gastrovascular space*. This is partly divided by membranous partitions, or *mesenteries*, that start from the inner surface of the column wall and project centrally. From the inner edge of the mesenteries come

the nettling filaments, or acontia, already mentioned. The line of attachment of a mesentery to the column wall is often marked, as in the Edwardsiæ (Fig. 1), by a depressed line or furrow on the exterior of the column.

A second internal feature of importance is the *sphincter*, or circular muscle, in the region between the oral disk and the column. This muscle, by virtue of which the upper part of the column may be puckered over the oral disk when this is contracted, lies either in the intermediate layer of the body wall (mesoglœa), as in the Paractidæ, or in the inner layer (endoderm), as in the Bunodidæ. These distinctions are not easily made out unless the region in question is examined microscopically. When the sphincter is poorly developed, as in the Boloceridæ, the polyps, even when contracted, usually leave their tentacles exposed.

The following key gives the species of Actiniaria recorded for North America at depths within 100 fathoms of the surface and occurring north of Florida on the east coast, and north of southern California on the west coast. In indicating the geographical range the following abbreviations have been used:

N., Arctic Ocean to Cape Cod.
M., Cape Cod to Cape Hatteras.
S., Cape Hatteras to Florida.
A., Arctic Ocean to Puget Sound.
P., Puget Sound to San Francisco.
D., San Francisco to Southern California.

KEY TO THE TRIBES OF THE SUBORDER ACTINIARIA.

1. Colonial . . . . . Zoantheæ 58
1. Not colonial 2
2. Tentacles in two circles, one marginal (principal) and the other circumoral (accessory) . . . . . Ceriantheæ 56
2. Tentacles in a single circle 3
3. Column smooth, wrinkled, or with longitudinal furrows, at least twelve in number (six pairs of mesenteries) . . . Hexactiniæ 7
3. Column with eight longitudinal furrows (eight mesenteries) Edwardsiæ 4

GENERA AND SPECIES OF EDWARDSIÆ.

4. Tentacles sixteen or fewer . . . . . Edwardsia 5
4. Tentacles more than sixteen, usually at least twenty-four, Edwardsiella 6
5. Polyp slender; tentacles sixteen; non-parasitic
Edwardsia elegans Ver., N., low water

5. Polyp very slender, length 30 mm., diameter 1.5 mm.; tentacles sixteen; parasitic on *Mnemiopsis leidyi* . . *E. leidyi* Ver., M.[1]
6. Polyp slender, length 125 mm., though capable of contracting to 35 mm., diameter 4 mm.; tentacles twenty to thirty-six; column with a brownish investment, except at aboral end, which is naked
E. sipunculoides (Stimp.) Andres, N., low water (Fig. 1)
6. Polyp slender, length 25–35 mm., diameter 2.5–3 mm.; tentacles twenty-four to thirty; column including aboral end with a brownish investment . . . . *E. lineata* (Ver.), M., 4–12 fathoms

FIG. 1.—*Edwardsiella sipunculoides* (Stimp.) Andres. After Verrill.

FAMILIES OF HEXACTINIÆ.

7. Pedal disk absent . . . . . Ilyanthidæ 11
7. Pedal disk present 8
8. Acontia present . . . . . Sagartidæ 38
8. Acontia absent 9
9. Sphincter diffuse and weak . . . . . Boloceridæ 18
9. Sphincter strong 10
10. Sphincter endodermal (column usually tuberculated) Bunodidæ 20
10. Sphincter mesoglœal (column usually not tuberculated) Paractidæ 31

GENERA AND SPECIES OF ILYANTHIDÆ.

11. Conchula (proboscis) present . . . . . Bicidium 12
11. Conchula absent 13
12. Polyp elongated, length 30 mm., diameter 6 mm., longitudinal sulcations twelve; tentacles twelve; usually parasitic on *Cyanea arctica*
Bicidium parasiticum Ag., N. (Fig. 2)
13. Column divided into three sections, an oral retractile capitulum, an intermediate scapus, and a pedal physa . . Halcampa 14
13. Column continuous, not divided into sections 15
14. Polyp elongated, length 25 mm., diameter 3 mm.; tentacles twelve
Halcampa farinacea (Ver.) Andres, N., 8–90 fathoms (Fig. 3)
14. Polyp slender; tentacles about twenty-four
H. pallida (Ver.) Andres, N., low water
15. Tentacles blunt or club-shaped . . . . . Eloactis 16
15. Tentacles tapering to a point . . . . . Ilyanthus 17
16. Polyp much elongated, length 200–250 mm., which may by contraction be reduced to 75 mm., diameter 18 mm., longitudinal sulcations twenty; tentacles twenty
Eloactis producta (Stimp.) Andres, M., low water (Fig. 4)

[1] Known only as an immature form.

17. Polyp elongated, tapering from oral to aboral end, length 25 mm., greatest diameter 6 mm.; tentacles thirty-six, in two imperfect rows *Ilyanthus lævis* Ver., N. (Fig. 5)

17. Polyp rather slender, tapering from oral to aboral end, length about 90 mm., greatest diameter 18 mm.; tentacles numerous, in several rows . . . . . *I. chloropsis* Ver., S.

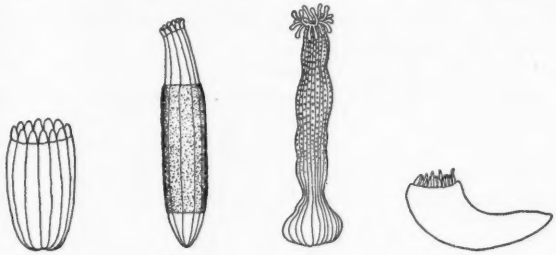

FIG. 2. FIG. 3. FIG. 4. FIG. 5.

FIG. 2.— *Bicidium parasiticum* Ag. After Verrill.
FIG. 3.— *Halcampa farinacea* (Ver.) Andres. After Verrill.
FIG. 4.— *Elvactis producta* (Stimp.) Andres. After Verrill.
FIG. 5.— *Ilyanthus laevis* Ver.

SPECIES OF BOLOCERIDÆ.

18. Tentacles with strong sphincter muscles at base (often deciduous) Bolocera 19

19. Polyp broad and low, height about 30 mm., diameter of oral disk about 200 mm.; tentacles several hundred, crowded, in some twenty indistinct rows . . *Bolocera multicornis* Ver., N., 45 fathoms

19. Polyp massive, height about 100 mm., diameter of oral disk 150–250 mm.; tentacles numerous, in some three concentric rows *B. tuediæ* (Johnst.) Gosse, N., 37–365 fathoms (Fig. 6)

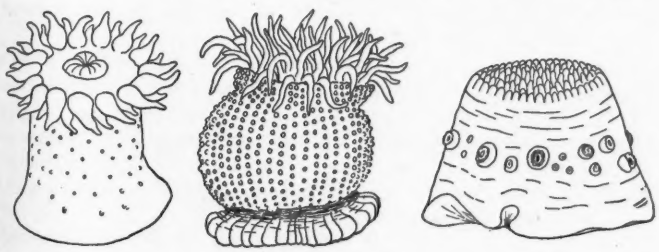

FIG. 6. FIG. 7. FIG. 8.

FIG. 6.— *Bolocera tuediæ* (Johnst.) Gosse. After Andres.
FIG. 7.— *Evactis artemisia* (Dana) Ver. After Dana.
FIG. 8.— *Epiactis prolifera* Ver. After Verrill.

GENERA AND SPECIES OF BUNODIDÆ.

20. Column perforated by numerous pores through which water may be discharged . . . . . Evactis 21
20. Column not perforated by pores 22
21. Polyp broad and low, diameter of oral disk 60 mm.; tentacles in three series . . . *Evactis artemisia* (Dana) Ver., P. (Fig. 7)
22. Column surrounded at its middle by a band of egg pits Epiactis 23
22. Column without egg pits 24
23. Polyp 10 mm. in height, diameter of aboral disk 12 mm.; tentacles about ninety-six; egg pits as many as thirty to forty, often containing young, which then resemble buds
Epiactis prolifera Ver., P. (Fig. 8)
24. Column with scattered tubercles 25
24. Column with tubercles in longitudinal rows 28

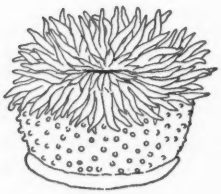

FIG. 9.

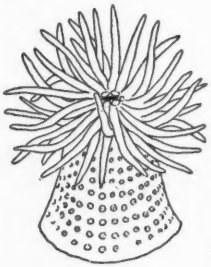

FIG. 10.

FIG. 9. — *Tealia crassicornis* (Müll.) Gosse. After Andres.
FIG. 10. — *Bunodes stella* Ver. After Verrill.

25. Oral edge of column with marginal spherules . . Phymactis 26
25. Oral edge of column without marginal spherules . . Tealia 27
26. Polyp 50 mm. in height, diameter of oral disk 38 mm.; tentacles ninety-six, in four circles
Phymactis cavernata (Bosc) Andres, S., between tides
27. Polyp 50 mm. in height, diameter of oral disk 120 mm.; tentacles 160
Tealia crassicornis (Müll.) Gosse, A., N., 16–40 fathoms (Fig. 9)
28. Tubercles forming rows on column from oral to aboral end Bunodos 29
28. Tubercles limited to oral portion of column . . Aulactinia 30
29. Polyp 50 mm. in height, diameter of oral disk 35 mm.; tentacles large, forty-eight to seventy-two
Bunodes stella Ver., N., tide pools (Fig. 10)
30. Polyp columnar, height 150 mm., greatest diameter 35 mm.; tentacles ninety-six, in four circles
Aulactinia capitata Ver., M., S., low water

GENERA AND SPECIES OF PARACTIDÆ.

31. Inner tentacles many times longer than outer . Actinostola 32
31. All tentacles of about the same length 33
32. Polyp massive, height 150–180 mm., diameter of oral disk 200–250 mm.; tentacles numerous
Actinostola callosa Ver., N., M., 45–300 fathoms (Fig. 11)
33. Diameter of pedal disk much less than that of column Ammophilactis 34

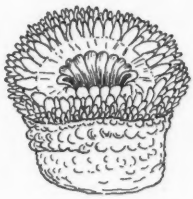

FIG. 11.

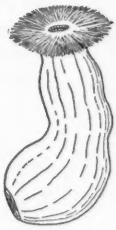

FIG. 12.

FIG. 11. — *Actinostola callosa* Ver. After Verrill.
FIG. 12. — *Ammophilactis rapiformis* (Les.) Ver. After Verrill.

33. Diameter of pedal disk as great as that of column or greater . 35
34. Height of column 80 mm., diameter of oral disk 25 mm., of column 12–25 mm., of pedal disk 10–12 mm.; tentacles numerous (144 or more)
Ammophilactis rapiformis (Les.) Ver., M., tide pools (Fig. 12)
35. Sphincter well developed, collar pronounced, especially in contracted specimens . . . . . Stomphia 36
35. Sphincter poorly developed, collar scarcely noticeable, even in contracted specimens . . . . . Paractis 37

FIG. 13.

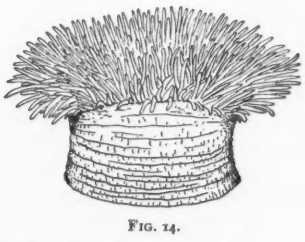

FIG. 14.

FIG. 13. — *Stomphia carneola* (Stimp.) Ver. After Verrill.
FIG. 14. — *Paractis perdix* Ver. After Verrill.

36. Height of column 50 mm., diameter of oral disk about 37 mm.; tentacles ninety-six or more, in two or three crowded marginal rows
Stomphia carneola (Stimp.) Ver., N., 8–35 fathoms (Fig. 13)

37. Height of column 75–100 mm., diameter of oral disk about 125 mm.; tentacles very numerous (about 384)
Paractis perdix Ver., M., 62–192 fathoms (Fig. 14)

SUBFAMILIES OF SAGARTIDÆ.

38. Column divided into two segments, an oral capitulum and an aboral scapus; cinclides usually absent . . . . Phellinæ 53
38. Column undivided; cinclides usually present . . Sagartinæ 39

GENERA AND SPECIES OF SAGARTINÆ.

39. Column wall smooth or with only very slight evidence of tubercles, no cinclidial tubercles 40
39. Cinclidial tubercles present 48
40. Oral disk lobed, tentacles very numerous . . Metridium 41
40. Oral disk not lobed, tentacles numerous . . . Sagartia 42

SPECIES OF METRIDIUM.

41. Column 100 mm. in height, diameter of oral disk 75 mm.; tentacles very numerous, the central ones longest *Metridium marginatum* (Les.) M. Edw., N., M., low water to 90 fathoms (Fig. 15)
41. Polyp as in preceding species but with tentacles longer and more slender . . . . *M. fimbriatum* Ver., P., low water[1]

SPECIES OF SAGARTIA.

42. Tentacles peripheral, so that more than half of the oral disk is exposed 43
42. Tentacles covering oral disk so that very little or none of it is exposed 44
43. Height of column 15–25 mm., diameter 10–20 mm.; tentacles about fifty, in two, three, or more rows, rather small
Sagartia spongicola Ver., M., 72–158 fathoms
44. Height of column less than 10 mm. 45
44. Height of column about 20 mm. 46
44. Height of column 40 mm. or more 47
45. Surface of column smooth, height 5–8 mm., diameter 4–6 mm.; tentacles eighty-four, in four rows, central ones longest
S. luciæ Ver., M., N., tide pools
45. Surface of column broken by longitudinal and transverse furrows, height 6 mm., diameter of pedal disk 10–14 mm., of oral disk 6 mm., tentacles long, sixty-four, in four rows
S. pustulata McMur., M., shallow water

[1] Probably synonymous with *M. marginatum*.

46. Height of column 20 mm., diameter 3–4 mm.; tentacles forty-eight, in four rows . . . *S. gracillima* McMur., M., shallow water
47. Height of column 63 mm., diameter 15 mm.; tentacles about sixty, rather short, length less than the diameter of the oral disk
S. modesta Ver., M., low water (Fig. 16)
47. Height of column 40 mm., diameter 25–35 mm.; tentacles numerous, in three to five rows, longer than the diameter of the oral disk
S. abyssicola (Kor. and Dan.) Ver., N., M., 75–640 fathoms

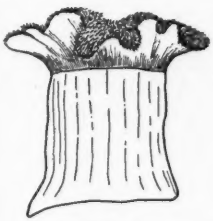

FIG. 15.

FIG. 16.

FIG. 17.

FIG. 15.—*Metridium marginatum* (Les.) M. Edw.
FIG. 16.—*Sagartia modesta* Ver. After Verrill. On the sides of the column several twisted acontia are seen, their points of exit marking the positions of cinclides.
FIG. 17.—*Cylista leucolena* (Ver.) Andres. After Verrill.

OTHER SPECIES OF SAGARTINÆ.

48. Cinclidial tubercles small, in irregular vertical lines . . Cylista 50
48. Cinclidial tubercles large 49
49. Cinclidial tubercles forming a band around middle of column
Aiptasia 51
49. Cinclidial tubercles forming a band around pedal end of column
Adamsia 52
50. Height of column 63 mm., diameter 10 mm.; tentacles ninety-six, in five rows, slender, and longer than twice the diameter of the column
Cylista leucolena (Ver.) Andres, M., shallow water (Fig. 17)
51. Height of column 38 mm., diameter of oral disk 18 mm.; tentacles ninety-six, in four rows, length of inner tentacles 20 mm., of outer ones 6 mm. *Aiptasia pallida* (Ver.) Andres, S., shallow water
52. Height of column 75 mm., diameter 43 mm.; tentacles very numerous (500 or more in large specimens); on dead shells inhabited by hermit crabs
Adamsia tricolor (Les.) Duch. and Mich., S., shallow water
52. Height of column 10–14 mm.; tentacles numerous, in two circles; young on dead shells inhabited by hermit crabs (*Catapagurus socialis* Smith), later the shell may be dissolved, the polyp having formed a horny hood in which the crab protects its abdomen
A. sociabilis Ver., M., 76–410 fathoms (Fig. 18)

GENERA AND SPECIES OF PHELLINÆ.

53. Capitulum with longitudinal ridges, scapus strongly tuberculate
Actinauge 54

53. Capitulum smooth, scapus granulated . . . . Phellia 55

54. Height of column 80–150 mm., diameter 50–100 mm. ; tentacles ninety-six, in five rows
Actinauge verrillii McMur., N., M., S., 50–506 fathoms (Fig. 19)

FIG. 18.

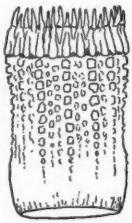

FIG. 19.

FIG. 20.

FIG. 18. — *Adamsia sociabilis* Ver. After Verrill. The cinclidial tubercles that occur near the pedal margin of the column in this species are not represented in the figure.
FIG. 19. — *Actinauge verrillii* McMur. After Verrill.
FIG. 20. — *Phellia arctica* Ver. After Verrill.

55. Height of column (contracted) 18 mm., diameter of oral disk 5 mm. ; scapus with rough, thick cuticula ; below the middle are several transverse rows of large egg pits
Phellia arctica Ver., A., 30 fathoms (Fig. 20)

SPECIES OF CERIANTHEÆ.

56. Aboral end rounded and provided with a pore ; aboral portion of column contained within a secreted tube . . Cerianthus 57

57. Column cylindrical, tapering aborally, length 600 mm. (contracted, 200 mm.), diameter of column near middle, 25 mm. ; marginal tentacles (125 or more) 32–38 mm. in length, circumoral tentacles 18 mm. in length
Cerianthus americanus Ver., M., S., shallow water (Fig. 21)

FIG. 21.

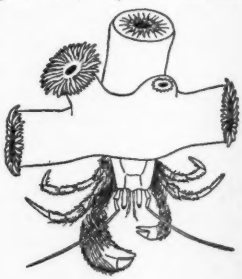

FIG. 22.

FIG. 21. — *Cerianthus americanus* Ver. After McMurrich.
FIG. 22. — *Epizoanthus americanus* Ver. After Verrill.

57. Column cylindrical, tapering aborally, length 450 mm., diameter 40 mm.; tentacles very numerous; marginal tentacles of different lengths, outer ones 25 mm. long, inner ones 56 mm. long; circumoral tentacles 25 mm. long, in several rows

C. borealis Ver., N., M., 7–150 fathoms

SPECIES OF ZOANTHEÆ.

58. Surface of body more or less incrusted with sand grains

Epizoanthus 59

59. Colonies of from three to ten or more polyps growing out of a common flesh; height of polyp about 25 mm.; tentacles thirty-eight or more; attached to stones or to dead snail shells inhabited by hermit crabs (in many instances the shelly material has disappeared, leaving the common flesh of the colony to form an investment for the crab)

Epizoanthus americanus Ver., N., M., 28–466 fathoms (Fig. 22)

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'63 *Journ. Boston Soc. Nat. Hist.* Vol. vii, p. 525.

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'94 *Proc. U. S. Nat. Mus.* Vol. xvi, p. 119.
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'68 *Proc. Essex Inst.* Vol. v, p. 315.
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'73 *Report U. S. Fish Commission* 1871–72. P. 295.
'74 *Proc. Amer. Assoc.* Vol. xxii, p. 340.
'80 *Proc. U. S. Nat. Mus.* Vol. ii, p. 165.
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REVIEWS OF RECENT LITERATURE.

GENERAL BIOLOGY.

Woods Holl Lectures for 1899.[1] — No clearer indication of the drift of affairs at the Marine Biological Laboratory at Woods Holl can be found than that contained in the volume of lectures for the past year. The growing interest in the station as a botanical center is shown in the fact that, while in 1898 no botanical lectures were published, in the past year one-fourth of the lectures are by botanists. D. H. Campbell spoke on the evolutions of the sporophyte in the higher plants; the importance of fossil plants was emphasized by D. P. Penhallow; and D. T. Macdougal discussed some factors in distribution and the significance of mycorrhizas. Animal psychology was represented by two lectures by E. Thorndike, one on instinct, and the other on associative processes in animals, and by a lecture by H. S. Jennings, on the behavior of unicellular organisms. "Some Governing Factors usually neglected in Biological Investigations," by A. Hyatt, and "The Aims of the Quantitative Study of Variation," by C. B. Davenport, were both contributions to the field of general biology. Physiology was represented by A. Mathews's paper on the physiology of secretion and J. Loeb's interesting contribution on the nature of fertilization, while from the experimental standpoint T. H. Morgan's lecture on regeneration is of importance. Cytology, which heretofore has been paramount, was represented by only two papers: "Nuclear Division in Protozoa," by G. N. Calkins, and "The Significance of the Spiral Type of Cleavage," by C. M. Child. Other interesting lectures were one on blind-fishes, by C. H. Eigenmann, and one on the development of color in moths and butterflies, by A. G. Mayer. The series of lectures, taken as a whole, shows an unusually well-balanced development of biological interests.

P.

Animal and Plant Colors. — Color in nature has been made the subject of an interesting volume of some 350 pages, by Marion I.

[1] *Biological Lectures* from the Marine Laboratory, Woods Holl, Mass., 1899. Boston, Ginn & Company, 1900. 282 pp.

Newbigin.[1] The introductory portion, which is included in the first two chapters, deals with the well-known distinctions between pigmental and structural colors and a further classification within these two groups. It also contains a brief account of light-producing organisms. Then follows a series of chapters devoted to the consideration of the color phenomena in plants and in the various groups of the animal kingdom, special attention being paid to butterflies and to birds. As a result of this survey, the author states "that it is as yet impossible to give a definite physiological explanation of the origin of pigment; that it is practically impossible to classify pigments in a logical manner; that most of the problems connected with the subject are entirely unsolved." After this general denial of results, except from a simply descriptive standpoint, the author devotes a closing chapter to the theoretic aspects of the subject. This gives in an impartial way the explanations of the origin of different types of coloration as advocated by such Darwinists as Poulton, by such Lamarckians as Cunningham, and by those who, like Wallace, occupy intermediate grounds; Simroth's fanciful conceptions occupy what seems to us an undue amount of space. The Darwinian views are criticised from the standpoint of Piepers's able paper, and the views of the non-Darwinians are dismissed because they imply the inheritance of acquired characters.

The volume shows little originality, but the very fact that the author has no special views of her own to advocate allows her to give the views of others in a more impartial way. The book is concluded with a good list of references, an index of authors, and an index of subjects. It is exceptional in having escaped the hands of the chromo-lithographer or, in fact, those of any illustrator. P.

The Plankton of the Elbe, near Dresden, has been studied by Dr. B. Schorler[2] in collections made at eleven intervals, from April to November, 1898, in the main stream and in three contiguous bays. The current in the Elbe ranges from 40 to 190 cm. per second, and the plankton was less abundant in the main channel than it was in the quieter water of the adjacent bays, thus illustrating Schröder's law that the volume of plankton in a stream is inversely proportional to the rate of the current. In all, 143 species were found, of which

[1] Newbigin, M. I. *Color in Nature, a Study in Biology.* London, J. Murray, 1898. xii + 344 pp.

[2] Schorler, B. Das Plankton der Elbe bei Dresden, *Zeitschr. f. Gewässerkunde,* Bd. iii (1900), pp. 1–27.

88 are plants, and about one-third are reported as common. Like that of the Oder, the Elbe plankton is characterized by the predominance of diatoms, especially in spring and autumn. In the main stream the phytoplankton greatly exceeds the zoöplankton in volume and variety and plays a very important part in the self-purification of the river water. Access of sewage does not have a deleterious effect upon the plankton. Dr. Schorler does not regard the Elbe plankton as autonomous, but dependent for its maintenance upon accessions from adjacent bays and lagoons, and from tributary waters. The littoral fauna and flora also contribute to the potamoplankton. In the still water of the bays an abundant animal plankton of rotifers and crustaceans was found, which reached the unusual volume of 112 c.c. per cubic meter of water.

C. A. K.

ZOÖLOGY.

New Edition of "Wilson's Cell." — The penalty that an author must pay for writing a successful text-book is that of revision, and this penalty has been conscientiously and fully met by Dr. Wilson[1] in the new edition of his text-book on the cell. The first edition was published in 1896 and contained 371 pages and 142 illustrations. The second edition, now before us, contains upwards of a hundred additional pages and nearly fifty new illustrations. Minor changes appear on almost every page, and some sections have been entirely recast. The more striking changes reflect the steady growth of cytological knowledge. Thus, the centrosome, which in the first edition was treated as a permanent organ of the cell, is, in view of the most recent work on both plants and animals, regarded now as of mixed character, in that it sometimes exhibits the peculiarities of a permanent organ by being inherited from cell to cell, and at other times is strictly temporary. The statements as to the finer structure of protoplasm have also been considerably modified. In the first edition Dr. Wilson favored the fibrillar theory, though without denying that other views might contain more or less truth. In the second edition the alveolar theory and even the granular theory have gained sufficiently to be fairly abreast their former rival. This change of

[1] Wilson, E. B. *The Cell in Development and Inheritance.* New York, The Macmillan Company, 1900. Second edition, xxi + 483 pp.

view is presumably largely due to Dr. Wilson's own work, and the opinion now expressed in his book is that the various types of structure assumed for protoplasm by different schools may in reality represent different phases in the functional activity of this substance. So thoroughgoing and complete has been the revision for the new edition that it will form an invaluable aid to every one interested in modern aspects of cytology.

P.

Intracellular Canals in Ganglion Cells. — The system of canals within the protoplasmic substance of ganglion cells, to which Holmgren has recently called attention, has been identified by Bethe[1] in the spinal ganglion cells of the rabbit. That these canals have a wall of their own as contrasted with the protoplasm of the cell in which they lie seems doubtful. They can be traced, however, beyond the limits of the cell, and in such regions show an undoubted wall; but this contains no nuclei, and hence its histological composition is in doubt. No connection between the canals and blood vessels could be demonstrated, the structures in this respect differing from the tubes discovered by Adamkiewicz. The physiological significance of these canals, whether they be lymph spaces or other such structures, is still to be ascertained.

P.

Vertebrate Anatomy. — Professor W. S. Miller[2] has edited and published under one cover four papers on vertebrate anatomy, the work having been done for the most part by students in his laboratory. The first deals with the histology of the lung of Necturus, the second with this animal's vascular system, and the third with its brain. These three contributions are simple descriptive statements of the more obvious facts that they have to deal with, and are not far-reaching in any direction. The fourth paper takes up the question as to whether there are preformed natural openings on the lining of the body cavity of the cat, a question which is answered in the negative. The papers on the whole are not of a high order, and, in fact, it is difficult to justify the publication of the first three. Nor is the editorial work well attended to, as the following sentence

[1] Bethe, A. Einige Bemerkungen über die "intracellulären Kanälchen" der Spinalganglienzellen und die Frage der Ganglienzellenfunction, *Anat. Anzeiger*, Bd. xvii (1900), pp. 304–309.

[2] Miller, W. S. Contributions from the Anatomical Laboratory of the University of Wisconsin, *Bull. Univ. Wis.*, Science Series, vol. ii (1900), pp. 199–245, Pls. III–XV.

shows (p. 203): "The nuclei of these cells do not seem to occupy any one characteristic position, but are found in all parts of the cell."

P.

Elementary Physiology.[1] — This small book consists of a series of outline headings in physiology for schools, with references to standard books where information on the subjects can be had, as well as a set of laboratory exercises in this science. The grade of the work can be judged from the fact that on page 2 ten book references are given, of which six lead the reader to Shepard's *Chemistry* and inform him that "any other good chemistry will answer just as well," and four direct him to the "Dictionary, any unabridged." The laboratory exercises equal the outlines. On page 140 we are instructed to "get from a butcher either the head of some mammal which still has the eyes uninjured or some eyes that have been carefully removed," and, after certain preliminary steps, to pour out the vitreous humor and observe "the yellow spot, or area of acute vision." As an obvious yellow spot is limited among mammals to human beings and monkeys, one is naturally inquisitive about the butcher shops in the neighborhood of the State Normal School of Minnesota. Unpretentious as the book is, one must regret that it departs so far from facts.

P.

Formaldehyde. — The properties of formaldehyde have been made the subject of an interesting communication by Neuville.[2] An historical sketch of its discovery, uses in biology, as well as an account of its method of preparation and its physical and chemical properties, precede a discussion of its action on albuminoids and color compounds. Gelatin, when subjected to its action, is rendered insoluble, though still remaining flexible. This action is not a simple coagulation, but a real chemical action, for, if the solution of formaldehyde used is weak, all traces of this reagent disappears when considerable gelatin is mixed with it. On the other hand, blood serum is less easily coagulated by heat, etc., in the presence of formaldehyde. Its action on pigments is very diverse. The coloring matters of bile and of urine seem unaffected by it, but those which give to organisms their normal colorations are so differently

[1] Cox, U. O. *A Syllabus of Elementary Physiology, with References and Laboratory Exercises.* Mankato, Minn., Free Press Printing Co., 1899. viii + 167 pp.

[2] Neuville, M. H. Sur la formaldéhyde, *Bull. Soc. Philomathique, Paris,* Sér. 9, T. i (1899), pp. 104–121.

affected that no rules can be laid down for its use, though it is certainly less of a decolorizer than alcohol. Its considerable antiseptic and toxic properties are finally described. P.

Jordan and Evermann's Fishes, Part IV.[1] — The last volume of this great work has just been issued. It contains the additional Addenda and the plates illustrating nearly one thousand species of American fishes. This entire work is in one sense a revision of "Synopsis of Fishes of North America" (*Bulletin No. 16*), by Jordan and Gilbert. *Bulletin No. 16*, however, included only the fishes then known to inhabit North America north of the Tropic of Cancer. Aside from the Addenda, it forms one volume of 866 pages and records 1339 species. The Addenda contain 108 more pages, which adds about 160 more species. The volume contains no plates. The present work includes all salt-water fishes which inhabit America north of the equator, and all fresh-water fishes north of the Isthmus of Panama. Aside from the Addenda, the work contains 2744 pages and describes 3127 species of fishes. The Addenda in Vol. III contain 130 pages, and Vol. IV has an additional Addenda of 160 pages. Vol. IV also includes a complete table of contents for all species listed in the four volumes. "From this systematic arrangement it is seen that the fish fauna of North and Middle America, as now understood by the present authors, embraces 3 classes, 30 orders, 225 families, 1113 genera, 325 subgenera, 3263 species, and 133 subspecies." This is by far the most extensive and most useful work ever written on American fishes. It contains descriptions of all the species known from the region which it covers and analytical keys to facilitate identification.

Attention is often called to doubtful species in footnotes, and in many cases the original description is given. This tendency not to place in synonymy doubtful species, when chances are even that a careful study will prove them valid, is to be commended. It will no doubt require a careful study of variation to dispose properly of many doubtful species and many subspecies. It is best to let them stand as first indicated until this sort of study can be made. The next century will witness a great deal of study of the variation of animals, which, with its complement of morphological study, will eventually reduce the work of the classification to a proper basis.

[1] Jordan, D. S., and Evermann, B. W. The Fishes of North and Middle America, *Bull. U. S. Nat. Mus.* (1900), Pt. iv, No. 47, ci + 3137–3313 pp., 392 plates.

The authors will invite some criticism because of their extensive use of genera and subgenera. Any characteristics which will group species must be noticed, but whether or not as much prominence should be given many of these groups by giving generic or subgeneric names will remain as a matter of opinion. If in this respect the authors have gone to one extreme, they have chosen the more scientific one. The retention of common names will prove very useful. The type of each genus is indicated, as is also the locality of the type of each species. The museum in which the type is preserved is also given.

In the mechanical construction of the book we regret that the family and generic names are not at top of the page, as in *Bulletin No. 16;* a useful feature has here certainly been omitted. The authors have done well a great work, and *Bulletin No. 47*, for many years to come, will represent the ideas of our best American ichthyologists concerning the classification of our American fishes.

S. E. MEEK.

The Monascidians of the Bremer Expedition. — The report on this group of animals is by Dr. Robert Hartmeyer (*Zool. Jahrb.*, Abth. f. System. Geog. u. Biologie, Bd. XII (1899), pp. 433–520).

In all, eleven species are treated, three of which are new. The genus Dendrodoa, the validity of which has been doubted by several writers, is accepted by the author and a new species added.

It is pointed out that, as between the northern and more southern range of each species, in every case the latter were taken in the greater depths of water.

The author thinks that the distribution of the species confirms the idea of circumpolar range of species. The same writer reported some time ago (*Zool. Anz.*, Bd. XXII (1899), Nr. 590, p. 268) that the two Arctic species in Dendrodoa of the collection retain the larvæ in a brood pouch until a late stage of life. This method of larval protection is not uncommon among compound Ascidians, but is known in only one or two other instances among the simple ones. The author points out that the tendency of Arctic marine animals to thus retain the young for protection is seen in various groups; and that, consequently, the habit in these two species of Monascidians is only in keeping with a general physiological adaptation; that, in all probability, other species will be found to possess the same peculiarity. I may add that I have recently observed the same thing in a species of Ascidia from Alaskan waters. W. E. RITTER.

Relation between Nervous and Glandular Tissue in Ascidians. — It is now fully established that the brain and neural gland in the ascidian embryo develop from a common Anlage. Professor M. M. Metcalf (*Biol. Bull.*, Vol. I, No. 1) has studied the relation of the nerve and duct which spring from the brain and gland, respectively, and run along the median line on the partition wall between the pharynx and cloaca, and finds a closeness of relations there between the two tissues that is quite as remarkable as is the fact of their common origin.

In *Amaroncium constellatum*, for example, a rudimentary duct starts out from the gland, but soon loses its lumen and becomes so intimately united with a strand of cells from the brain that it is impossible to tell whether the common mass should be regarded as coming from brain or gland.

W. E. RITTER.

The Life Cycle of Adelea Ovata, a coccidium parasitic in the digestive epithelium of Lithobius, has been described by Siedlecki.[1] When the sporocysts, which are resistant stages, are taken into the intestine of the host, the two sporozoites are liberated from the cyst and enter the epithelium, where, by a process of endogenous generation, they give rise to two sexually different stages, the microgametocytes and the macrogametes. These pass into the lumen of the intestine, where a smaller microgametocyte attaches itself to a larger macrogamete and undergoes two divisions, producing four microgametes. These two divisions differ in character, the first being a regular division resulting only in a quantitative reduction of the chromatin, while the second is irregular and apparently reduces the number of chromosomes. The nucleus of the macrogamete also rejects a portion of its chromatin. A single microgamete then unites with the macrogamete, and divisions follow which result in the formation of the resistant sporocysts.

C. A. K.

Notes. — In the Prague *Sitzungsberichte* Dr. Mrazek describes the destruction of cysts of the sporozoan Glugea in the spinal cord of Lophius by the phagocytes of the host which press through the walls of the cyst and devour the spores.

The limnetic Peridinidæ of Norway are discussed by Huitfeldt-Kaas in the Christiania *Skrifter*. Five species are reported, of

[1] Siedlecki, M. Étude cytologique et cycle évolutif de Adelea ovata Schneider, *Ann. de l'Inst. Pasteur* (1899), pp. 169–192, Pls. I–III.

which three are new. One of these, *Ceratium curvirostre*, resembles *C. kumaonense*, described by Carter in 1871, from Hindostan. The cosmopolitan *C. hirundinella* reaches its greatest development in Norwegian waters at the maximum summer temperature, in one instance attaining 50,000,000 per square meter of lake surface.

The inaugural address of Rektor Karl Brandt of the University of Kiel reviews the methods, progress, and problems of planktology, with special reference to the productivity of the sea. The poverty of the tropical oceans is correlated with the greater activity of denitrifying organisms in these waters, while the low temperature of the arctic seas hinders this process and greater fertility ensues.

The larval form of *Epischura lacustris*, a peculiar asymmetrical copepod of our Great Lakes, has been found by Professor C. D. Marsh in Green Lake in the winter months. The structure of the male abdomen and fifth feet are described in the *Transactions of the Wisconsin Academy*. The development of the larva indicates but a remote relation to Diaptomus. The asymmetry appears late in the development of the larva.

No. 3 of Vol. IV of the *American Journal of Physiology* contains the following articles: "The Occurrence and Origin of the Xanthine Bases in the Fæces," by W. H. Parker; "Physiological Studies on Mucine," by Levin; "On the Reactions of Certain Infusoria to the Electric Current," by R. Pearl; and "A Plethysmographic Study of the Vascular Conditions during Hypnotic Sleep," by E. C. Walden.

BOTANY.

The Cyclopedia of American Horticulture.[1] — The second volume of this important work, the first volume of which was noticed in the April number of the *American Naturalist*, proves equally good with its predecessor. Several of the larger genera of Cacti, elaborated (as to their garden representatives) by well-known students of the group, are of especial interest to American botanists; the chapter on the Grape is gratifying to those who hope for the improvement of other American fruits in as successful a manner as has been achieved in grapes; much of historic interest is to be found under Greenhouses and Horticulture; and the article on Insects forms an instructive little introduction to entomology. T.

[1] Bailey, L. H., and Miller, W. *Cyclopedia of American Horticulture* (in four volumes), vol. ii, E–M. New York, The Macmillan Company, 1900.

Notes. — Simultaneously with the concluding number of *Erythea* appears the first number of Vol. V of *Zoe*, which, after a suspension of several years, has resumed publication. In its new form *Zoe* is a thin octavo and apparently to be devoted to botany, so that, judging from this first number, it is a pretty close equivalent of the discontinued *Erythea*.

No. 19 of the *Contributions from the Gray Herbarium of Harvard University*, constituting No. 25 of the current volume of the *Proceedings of the American Academy of Arts and Sciences*, is by Mr. M. L. Fernald and deals with Mexican and Central American phanerogams, chiefly Labiatæ and Solanaceæ. Revisions are given of Salvia and Solanum of the subsection Torvaria, as represented in that region. The former comprises 217 species (contrasted with 118 recognized by Bentham in 1848, and 126 recognized by Hemsley in 1887). A very useful addition to the paper is an alphabetical list of collectors, with an indication of the disposal that has been made of their specimens.

In the *Atti del R. Istituto d'Incoraggiamento di Napoli* for 1899 Professor Comes publishes a monographic revision of the genus Nicotiana, illustrated by seven plates.

M. Crépin has a note on a probable hybrid of *Rosa carolina* and *R. nitida* in *Rhodora* for June.

Under the title "Economic Grasses, III," Professor Scribner issues, as *Bulletin No. 20* of the Division of Agrostology of the United States Department of Agriculture, an illustrated synopsis of the tribes and genera of Gramineæ that will prove useful to all students of that important family of plants.

Carex willdenowii and its allies are given comparative treatment by Holm in the *American Journal of Science* for July.

Under the title of "Icones Floræ Japonicæ" the College of Science of the Imperial University of Tokyo is issuing a folio consisting of plates, accompanied by bibliography in Latin or English, and descriptive text in Japanese. The first fascicle, published in February, illustrates *Prunus pseudo-cerasus*, α *spontanea*, and *Isopyrum nipponicum*.

Messrs. Ito and Matsumura have begun the publication of a Tentamen Floræ Lutchuensis in the *Journal of the Science College of the University of Tokyo*.

Professor Stanley Coulter contributes an annotated catologue of the spermatophytes and pteridophytes of Indiana to the twenty-fourth *Annual Report of the Department of Geology and Natural Resources* of that state.

In *La Semaine Horticole* of June 9 M. Rodigas states that in Paris are cultivated not far from 90,000 trees, the average duration of the principal species of which is placed as follows: horse-chestnut, 115 years; sycamore, 61; ailanthus, 54; locust, 42; linden, 24; Paulownia, 14. The mortality among the trees in the center of the city is said to be twice as great as in the suburbs, and the principal causes of their death are given as: (1) dust on the leaves; (2) reverberation of solar rays from buildings; (3) gas, etc., in the soil; (4) injury to trunks and branches; (5) lack of aëration of roots; (6) the use of salt after snow falls in winter.

The *Yearbook of the United States Department of Agriculture* for 1899, recently issued, contains a number of résumés of progress in science as applied to agriculture, by competent writers, which give the volume an unusual interest and value for the teacher's library.

The *Proceedings of the Society for the Promotion of Agricultural Science* for 1899 contains an index to the contents of the publications of that body during its existence that will greatly facilitate reference to the often valuable matter that they contain.

Der Tropenpflanzer for June contains an interesting article on cotton production and manufacture, illustrated by maps and the most effective graphic devices.

The application of photography to scientific illustration finds exemplification in Mr. Woods's paper on Stigmonose, a disease of carnations and other pinks, recently published as *Bulletin No. 19* of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture. Among other things the sucking apparatus of aphides, fixed *in situ*, is represented in leaf sections, and it is interesting to observe that these creatures afford a practical demonstration of the course of the flow of sap, since their beaks seek the fibro-vascular bundles of the leaves.

A biographical sketch of Edwin Faxon, accompanied by an excellent portrait, appears in *Rhodora* for July.

GEOLOGY.

The Yellowstone National Park.[1] — The final results of detailed geological investigation in the Yellowstone Park by Arnold Hague, geologist in charge of the survey, are to be published in a monograph consisting of several volumes. Part II of the series has been issued, containing descriptive geology of portions of the area and special papers on petrography and paleontology; several of these, notably those chapters by Professor Iddings. have already been printed in abstract, or more fully in annual rep[illegible] of the survey. The authors of the several chapters are: Arnold Hague on the Mesozoic ridges of the southern part of the park, J. P. Iddings and W. H. Weed on the Gallatin Mountains and the Tetons, Weed on the Snowy Range, Iddings on petrography, the rhyolites, and some description of portions of the Absaroka Range, C. D. Walcott and G. H. Girty on Paleozoic fossils, T. W. Stanton on Mesozoic fossils, and F. H. Knowlton on the fossil flora.

South of the park the Teton Range contains a nucleus of crystalline schists and gneisses overlain by flexed Paleozoic and Mesozoic strata; these were deeply eroded and covered by breccias and rhyolites, the latter forming vast flows, which constitute a large portion of the present Yellowstone plateau. In the Gallatin Mountains, northwest of the park, strata ranging from Cambrian to Cretaceous have been elevated, folded, and faulted, and at the close of the Laramie the rocks were invaded by dikes, sheets, and laccoliths of igneous rock. In comparing the rocks of Electric Peak and Sepulchre Mountain, the former coarsely crystalline and the latter volcanic, in close proximity, Iddings has determined that diorites may be chemically identical with andesites of different mineral composition. Like the Tetons, the Snowy Range, northeast of the park, has an archæan core bordered by sediments dipping toward the lavas.

In the southern part of the park a number of ridges of Cretaceous sandstone occur, with the rhyolites abutting against their upturned flanks. There are here several exposures of dacite or quartz-andesite, apparently older than the rhyolite. A sandstone near the base of Pinyon Peak contains Laramie plants; a conglomerate

[1] Geology of the Yellowstone National Park, *Monograph XXXII, U. S. Geological Survey*, Pt. ii, Descriptive Geology, Petrography, and Paleontology, by Arnold Hague, J. P. Iddings, W. H. Weed, C. D. Walcott, G. H. Girty, T. W. Stanton, and F. H. Knowlton. xvii+791 pp., 121 plates. Washington, 1899.

overlying the Laramie and beneath the earlier volcanics is here conspicuous and is believed to be of Eocene age.

An interesting physiographic feature described by Mr. Hague is the old outlet of Yellowstone Lake, which formerly drained off to the southward by way of Snake River, and sent its waters to the Pacific. The outflow was through Outlet Canyon, south of the lake, and this gorge was so obscured by forest and glacial drift that for many years it was not suspected as being so important a key to the physiography. It is described as a "broad, deep gorge, and throughout a long period of time evidently served as the channel for a rapid, powerful stream carrying a large volume of water. To-day its bottom is a flat, grassy meadow." . . . An old terminal moraine across the bottom of the canyon marks the course of the present continental divide. A mighty change was effected in late geologic times by the damming of the lake to the southward and its overflow through the decomposed rhyolite on the north, so that the whole vast basin was diverted to form Yellowstone River and drain to the Altantic. The Yellowstone canyon and falls are results of this natural accident.

Professor Knowlton's study of the fossil flora, largely collected from the Tertiary tuffs and breccias, is a valuable contribution to paleobotany. Many species new to science are described, and it is shown that the present flora of the park is wholly distinct from that of Tertiary time. "Climatic conditions must have greatly changed. . . . The climate during Tertiary time, as made out by the vegetation, was a temperate or subtemperate one, not unlike that of Virginia at the present time, and the presence of the numerous species of Ficus would indicate that it even bordered on subtropical."

The volume consists of 900 pages of heavy paper, exclusive of plates, and there are 121 plates, in part map folders and thick heliotypes. A book, 12 × 9 inches, of this thickness, is, to say the least, unwieldy, and it seems undesirable to bind together diverse material, by various authors, in such bulky tomes. The margins are unnecessarily wide, and a book of this sort is extremely difficult to handle, and absolutely useless for the geologist in the field. As all the chapters are distinct in authorship, and the sequence is of no especial significance, such a work might much better be bound in a number of smaller volumes by separate authors.

The microphotographs by Iddings are of unusual excellence, and most of the illustrations are good. The reconstruction of geologic cross-sections in the air (Pls. V, XXXII), for heights of 10,000 feet,

is unwarranted by the facts cited or actual sections shown. Illustration of the descriptive geology would be improved with more diagrammatic figures in the text. There is a prejudice among scientists against text-figures in monographs; it seems to the writer that brevity and precision are the first requirements of a modern scientific work, and sometimes a text-figure will save referring to a remote plate, or reading a page of otherwise obscure statement.

T. A. J., JR.

Maryland Weather Service.[1] — If the plans of the Maryland Weather Service and Geological Survey are carried out to a finish, that state will in a few years have the most complete record of natural resources ever made for a single area. The Weather Service proposes to investigate land forms, weather, water, climate, soil, forestry, crops, fauna, and flora; the Geological Survey is studying earth physics, rocks, and minerals. Both organizations are under the efficient management of Professor William Bullock Clark, supported by state funds and by a corps of scientific assistants picked from Johns Hopkins University.

The first volume of the Maryland Weather Service is issued in the same size and style as the Geological Survey, with lavish illustration in the form of maps, charts, half-tones, heliotypes, and colored plates. The colored cloud pictures of the Hydrographic Office are reproduced. In the introduction Professor Clark states the plan and organization of the service. Cleveland Abbe, Jr., has a chapter on the physiography of the state. Meteorology is treated by Cleveland Abbe, of the U. S. Weather Bureau, F. J. Walz, and O. L. Fassig. The same thorough reconnoissance of the field is shown in this volume as in the early volumes of the Geological Survey. Professor Abbe's chapter on Aims and Methods of Meteorological Work is a complete statement of modern methods of studying the weather, with illustrations of all the instruments used. Other chapters are historical, statistical, and bibliographical.

T. A. J., JR.

Experimental Geology.[2] — The course of public lectures given by M. Stanislas Meunier in the Natural History Museum of the Jardin des Plantes in 1898 has been published in a small volume in popular form. The work is divided into two parts; the first deals with experimental imitation of surface processes in geology, denudation,

[1] *Maryland Weather Service*, vol. i. Johns Hopkins Press, 1899.

[2] Meunier, Stanislas. *La géologie expérimentale.* Paris, 1899.

and sedimentation; the second with the chemical and mechanical processes of the earth's interior. The book is illustrated with fifty-six text-figures, mostly in illustration of apparatus now exhibited in the museum.

The experiments described are those which have been carried on in the author's laboratory, as stated in the preface; this being the case, it is unfortunate that the account of apparatus and method is so brief that it would frequently be impossible to reproduce an experiment from the description given. The arrangement of the book is geological, but the text deals almost wholly with laboratory experiments; the geological application is not always clear, and in other cases the demonstration seems self-evident. Thus, particles of quartz are placed on a marble slab under a stretched elastic band, a weight is placed above, and the elastic slowly released. "Striations are produced comparable to those of glaciers." The conclusion is stated that glaciers cannot move as they do without eroding their beds. Again, Élie de Beaumont is quoted as stating that deltas are characteristic and distinctive of the present epoch; M. Meunier is convinced, after experimental study of deltas, that analogous structures have always existed since sedimentation began —a conclusion not likely to be disputed. This elementary treatment of the subject, however, is perhaps justified by the popular quality of the work; the experiments are illustrative rather than conclusive.

T. A. J., Jr.

Maryland Geological Survey.[1] — The third volume of the *Maryland Geological Survey* has been promptly issued and is as thorough and well executed as the earlier volumes. The subject is highway investigation; Professor Clark, state geologist, contributes two chapters on organization and on the relation of the geography, geology, and climate of the state to road building. Excellent physiographic, geologic, and meteorologic maps of the state are presented, and microphotographs showing the structure of the principal rocks which may be used as road metals. St. G. L. Sioussat gives an interesting historical chapter on the development and influence of highway legislation in Maryland, and A. N. Johnson describes exhaustively the present condition of the state highways and methods of road construction. The last three chapters are by Professor Reid, on experimental tests, administration, and highway economy. The

[1] *Maryland Geological Survey*, vol. iii. Johns Hopkins Press, 1899. 461 pp., 35 plates.

volume is thoroughly indexed, and in an appendix are printed the laws of Maryland relating to highways. In this volume, as in the earlier ones, the wealth of illustration is an especially marked feature. Separate colored maps of every county show the different kinds of roads and the distribution of rocks available for road building. The chapters on construction, tests, and administration — about one-half the book — are a complete summary of modern road-making methods and have a wide interest outside of the state. The bibliographies are very complete, and the method of road administration of all the states of the Union and many foreign countries is concisely summarized. If publication by the state of an attractive book of instructions tends to produce good roads, Maryland, in this respect, is far in advance of other states.

T. A. J., Jr.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

BESSEY, C. E. The Modern Conception of the Structure and Classification of Diatoms, with a Revision of the Tribes and a Rearrangement of the North American Genera. *Trans. Amer. Micr. Soc.* Vol. xxi, pp. 61–86, Pl. V. — BEYER, GEO. E. Louisiana Herpetology, with a Check List of the Batrachians and Reptiles of the State and the Avifauna of Louisiana, with an Annotated List of the Birds of the State. New Orleans, 1900. 45 pp. Reprinted from *Proc. La. Soc. Nat.* — BRUNER, H. L. On the Heart of Lungless Salamanders. *Journ. of Morph.* Vol. xvi, No. 2, pp. 323–353, Pl. XV. — CALL, R. E. A Descriptive Illustrated Catalogue of the Mollusca of Indiana. *24th Ann. Rep. Dept. Geol.*, etc., *Indiana.* pp. 337–535, 78 plates. — CURRIE, ROLLA P. A New Bird of Paradise. *Proc. U. S. Nat. Mus.* Vol. xxii, No. 1204, pp. 497–499, Pl. XVII. — JORDAN, D. S., and EVERMANN, B. W. The Fishes of North and Middle America, Pt. iv. *Bull. U. S. Nat. Mus.* No. 47, ci + 3137–3313 pp., 392 plates. — MACOUN, J. Catalogue of Canadian Birds. Pt. i, Water Birds, Gallinaceous Birds, and Pigeons. *Geol. Survey Canada.* Ottawa, 1900. 218 pp. — MCCALLEY, HENRY. Report on the Warrior Coal Basin. *Geol. Survey Alabama.* Jacksonville, Fla., Vance Printing Company, 327 pp., map and figs. — MERRILL, G. P., and STOKES, H. N. A New Stony Meteorite from Allegan, Michigan, and a New Iron Meteorite from Mart, Texas. Vol. ii, pp. 41–68. — MILLER, G. S., Jr. The Giant Squirrels of Burmah and the Malay Peninsula. Vol. ii, pp. 69–77. — MILLER, G. S., Jr., Descriptions of Two New Squirrels from Tuong, Lower Siam. *Proc. Washington Acad. Sci.* Vol. ii, pp. 79–81. — MILLER, G. S., Jr. Preliminary Revision of the European Red-backed Mice. *Proc. Washington Acad. Sci.* Vol. ii, pp. 83–109. — OSBORN, H. F. Correlation between Tertiary Mammal Horizons of Europe and America, etc. *Ann. N. Y. Acad. Sci.* Vol. xiii, No. 1, pp. 1–72. — RANKIN, W. M. The Crustacea of the Bermuda Islands. *Ann. N. Y. Acad. Sci.* Vol. xii, No. 12, pp. 521–548, Pl. XVII. — SMITH, FRANK. Notes on Species of North-American Oligochæta. IV. On a New Lumbricid Genus from Florida, etc. *Bull. Illinois State Lab. Nat. Hist.* Vol. v, pp. 459–478, Pl. XLI. — SMITH, JOHN B. A Hundred New Moths of the Family Noctuidæ. *Proc. U. S. Nat. Mus.* Vol. xxii, pp. 413–495. — TRELEASE, WM. Some Twentieth-Century Problems. *Science.* Vol. xii, pp. 48–62.

Bulletin Johns Hopkins Hospital. Vol. xi, Nos. 112, 113. July–August. — *Journal Cincinnati Society of Natural History.* Vol. xix, No. 6. — *Insect World, The.* Vol. iv, No. 6. June. — *Science Gossip.* Vol. vii, No. 74. July.

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